Regular Article

Web-based pathology modules with virtual slides are effective for teaching introductory gastrointestinal pathology concepts

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A B S T R A C T

Pathology interns face a steep learning curve as they transition from medical school to residency. Innovative teaching tools are needed to effectively and efficiently bridge this gap. We created four online learning modules geared toward pathology interns, for use at the beginning of the gastrointestinal pathology rotation at our institution. Our modules covered introductory esophageal, gastric, small bowel, and colonic pathology. Each module incorporated photomicrographs and annotated virtual slides, and included pre- and post-module assessment questions and a link to an anonymous survey. Twelve interns completed the modules between 9/20/2019 and 12/31/2021, including 80% of the 2020–2021 intern class. Significant improvement in performance was seen between the pre- and post-module questions for the stomach, small bowel, and colon modules (p < 0.05 for all), with a trend toward improved performance with the esophageal module. Interns rated the modules highly and indicated that they would recommend the modules to their peers. While the modules were geared toward interns, due to the coronavirus-19 pandemic we expanded access to the modules to include medical students. Medical students also found the learning modules valuable and requested more modules in the future. We conclude that online learning modules are an effective tool for teaching pathology interns and are well-received by this group. Online modules can also be seamlessly incorporated into asynchronous medical student teaching.

Keywords: Gastrointestinal, Interactive, Modules, Online, Virtual microscopy, Web-based

Introduction

Pathology interns (first-year residents) face a steep learning curve as they transition from medical school to residency. While undergraduate medical education (UME) pre-clinical courses typically cover histology and pathology, these topics have been condensed with recent adjustments to medical school curricula. As a result, interns may enter pathology residency without a solid foundational knowledge of normal histology and common pathologic diagnoses. Pathology interns therefore tend to require more substantial support, such as additional didactic sessions and slide review at a multihedged microscope, to master fundamental UME-level concepts before advancing onto graduate medical education (GME)-level pathology concepts. This UME to GME knowledge gap may be magnified on high-volume anatomic pathology (AP) clinical services, including biopsy-rich rotations such as gastrointestinal (GI) pathology. At the Johns Hopkins Hospital (JHH) residency program, interns on the GI rotation are rapidly incorporated into the workflow with an abbreviated reinforcement of basic histology, brief introduction to subspecialty-specific disease entities, and limited review of the clinical service workflow.

In an attempt to bridge this gap between AP-specific undergraduate and graduate medical education for pathology residents at JHH, a weekly AP pathology intern conference was developed and formally included in the didactic series. This yearlong conference series systematically covers normal histology and pathology at an appropriate level for pathology interns, and is organized according to Dr. Diana Molavi’s book The Practice of Surgical Pathology: A Beginner’s Guide to the Diagnostic Process. The conference uses glass slide sets and is taught by second-through fourth-year residents. While intern conference is valuable for intern instruction, as well as for fostering collegiality between junior and senior residents, there are a few limitations. The most significant limitation is that the sequences of the intern conferences and clinical rotations are not aligned. Resident scheduling constraints and either the fading or loss of glass slides over years of use are additional challenges to this synchronous in-person method of teaching.

To further supplement intern AP education, we sought to create interactive online learning modules covering introductory GI pathology for asynchronous completion (on the learner’s own schedule, without an instructor present). Established benefits of this teaching modality include greater access to fundamental and core educational materials, standardization of content to ensure that all fundamental concepts are...
covered, and the ability to include interactive questions to increase engagement and assess learning. Annotated virtual slides, a valuable teaching tool in pathology education, have been one notable example of standardized content and content delivery in AP UME and GME.\textsuperscript{6,7} Previous studies of online modules covering topics in cytopathology, dermatopathology, and various other anatomic and clinical pathology topics have shown that web-based learning modules are effective for teaching pathology residents and are well-received by this group.\textsuperscript{8-10}

Herein, we describe our experience designing, developing, and piloting four online learning modules covering esophageal, gastric, small bowel, and colonic pathology. While our modules were designed as a teaching tool for pathology interns, we later made the modules available to medical students, due to the need for virtual learning during the coronavirus disease 2019 (COVID-19) pandemic. The online modules were included as part of a virtual surgical pathology elective at our institution, and later offered as supplementary content for the Genes to Society - Gastroenterology Block core pre-clinical course at the Johns Hopkins University School of Medicine (JHUSOM).\textsuperscript{11,12}

**Materials and methods**

Kern's six-step approach to curriculum development for medical education was utilized to guide the design, development, and piloting of four online learning modules. In brief, our process included problem identification and needs assessment, development of educational goals and objectives, designing educational strategies to meet these objectives, piloting and implementation, and evaluation of the curriculum.\textsuperscript{13}

**Problem identification and general needs assessment**

Our identified problem was a need for educational materials geared toward anatomic pathology interns. We chose to initially focus on GI pathology, as this is the practice area of three of the authors. Interns often rotate on the GI service prior to other core AP rotations and the GI-specific core resident lecture series only occurs every 16–18 months.

**Targeted needs assessment**

The pathology residency program at JHH previously implemented a weekly interactive glass slide-based intern conference, during which second-through fourth-year residents systematically review basic histology and introductory surgical pathology concepts by organ system. While this conference has many positive aspects, limitations include 1) a lack of alignment between the sequence in which topics are covered in intern conference and the interns’ clinical rotation schedules, 2) lack of standardization as the topics are covered by different residents each year, 3) scheduling challenges for interns and teaching residents, and 4) physical limitations of glass slide sets including fading, breakage, and loss of slides. We aimed to remedy these issues by supplementing the current intern teaching sessions with online modules available for asynchronous completion.

**Goals and objectives**

Our goal was to review basic GI pathology and introduce clinically relevant concepts utilizing a case-based approach. In general, introductory concepts included normal histology, mucosal injury patterns, common non-neoplastic and neoplastic diagnoses, and the principles of GI organ cancer grading and staging. Specific learning objectives were created for each module and are shown in Table 1.

**Development of educational strategies**

**Content selection**

In order to focus on high-yield material, we loosely structured the modules around the content covered in the chapters on esophageal, gastric, small bowel, and colonic pathology in Dr. Diana Molavi’s book, *The Practice of Surgical Pathology: A Beginner's Guide to the Diagnostic Process*.\textsuperscript{2} This content closely mirrors diagnoses frequently encountered on the JHH GI pathology clinical service. We organized topics in a logical sequence, beginning with normal histology, progressing to non-neoplastic and neoplastic pathology, and closing with an organ-specific introduction to the principles of grading and staging for primary gastrointestinal carcinomas. Diagnoses covered in each module are shown in Table 2.

**Creating a digital slide set**

Glass slides were obtained from the existing intern conference slide sets and a gastrointestinal pathology teaching set belonging to one of the authors (L.V.). Additional slides covering diagnoses of interest were located by searching our electronic medical record (Epic Beaker, Verona, Wisconsin) and our previous internal pathology database (Pathology Data System, PDS). Eighty-six slides (83 stained with hematoxylin and eosin, 2 histochemical stains, and 1 immunohistochemical stain) were scanned at 40X and digitized using Leica Aperio AT (Leico Biosystems Imaging, Inc., Buffalo Grove, Illinois) and Roche iScan HT (Roche Diagnostics International, Rotkreuz, Switzerland) scanners. Digitized slides were stored in the Johns Hopkins digital pathology slide repository powered by Proscia Concentriq version 2.2.4 (Philadelphia, Pennsylvania). All slides were de-identified, organized, and annotated by one of the authors (J.B.).

**Creating modules**

Two of the authors (J.B. and L.V.) created four modules covering esophageal, gastric, small bowel, and colonic pathology using iSpring Suite 9 (Alexandria, Virginia), a PowerPoint (for Microsoft Windows, Redmond, Washington) add-on program geared toward educators. For each diagnosis, a text description in bullet-point form covering relevant histologic and clinical features, a photomicrograph, and a link to a corresponding annotated virtual slide was included. In addition to this content, each module incorporated 4–5 pre-module questions to assess
baseline knowledge and 10 post-module questions (including the pre-module questions, presented a second time) to assess learning. The pre- and post-module cases also included virtual slides, although these were not annotated. Feedback for correct and incorrect answers was provided for the post-module questions only. At the end of each module, we included a link to a survey through Qualtrics (Seattle, Washington). Screenhots from the Colon Pathology Module are shown in Figs. 1 and 2.

**Implementation**

The modules were posted on an internal pathology department website at our institution on 9/20/2019, and could be accessed via computer at any time, within or outside of the hospital. As a pilot study, pathology interns rotating on the GI pathology service were provided with links to the modules at the beginning of their rotations. There was a specific focus on recruiting interns for our study during the 2020–2021 academic year, during which emails with links to the modules were consistently sent to interns at the beginning of each rotation. While the interns were encouraged to complete the modules, they were informed that this was not a required activity and would not factor into rotation evaluations, and were notified of our research study. This portion of our study was reviewed by the JHU SOM Institutional Review Board (IRB00224575), which classified our project as exempt research.

Although the modules were initially designed for pathology interns, they were later incorporated into medical student teaching. At the beginning of the COVID-19 pandemic, in-person rotations and instruction were halted and there was a critical need for virtual education materials for medical students. Our modules were included as required asynchronous content in a virtual surgical pathology course offered by the Johns Hopkins Department of Pathology, and directly supplemented virtual synchronous instruction.11 In the 2021–2022 academic year, JHU SOM medical students enrolled in a core pre-clinical gastroenterology course were also provided access to the modules as enhancement educational resources.

Table 2
Topics covered in each learning module.

| Esophagus | Stomach | Small bowel | Colon |
|-----------|---------|-------------|-------|
| Normal histology | Normal histology | Normal histology | Normal histology |
| Reflux esophagitis | H. pylori gastritis | Chronic peptic duodenitis | Inflammatory bowel disease |
| Eosinophilic esophagitis | Autoimmune metaplastic atrophic gastritis (AMAG) | Celiac disease | Acute self-limited colitis |
| Candida esophagitis | Chemical gastritis | Gastritis | Cytomegalovirus (CMV) colitis |
| Cytomegalovirus (CMV) esophagitis | Hyperplastic polyp | Cryptosporidiosis | Inflammatory polypl |
| Herpes simplex virus (HSV) esophagitis | Juvenile polyp | Whipple’s disease | Juvenile polypl |
| Barrett’s esophagus with and without dysplasia | Fundic gland polyp | Mycobacterium avium complex | Hyperplastic polypl |
| Adenocarcinoma | Gastric adenoma | (MAC) infection | Sensile serrated adenoma |
| Squamous dysplasia | Intestinal metaplasia with and without dysplasia | Peutz-Jeghers polypl | Tubular/villous adenoma |
| Squamous cell carcinoma | Adenocarcinoma | Duodenal adenoma | High grade dysplasia |

Fig. 1. Colon Pathology Module, covering cytomegalovirus (CMV) colitis. The module content includes a text description with a photomicrograph and a link to a corresponding virtual slide (A). A screenshot of the annotated virtual slide is shown, with cytomegalic cells circled (B, H&E, 40X). A post-module multiple choice question includes a photomicrograph and link to a virtual slide (C). A screenshot of the corresponding virtual slide shows cytomegalic cells, which are not annotated (D, H&E, 40X).
Evaluation and feedback

Intern assessment

Pathology intern performance on the pre- and post-module questions was reviewed to assess baseline knowledge and learning. For each intern who completed a module, the number and percentage of questions answered correctly on the pre- and post-module questions was recorded by one of the authors (J.B.), who kept this information confidential such that it was not shared with the faculty member responsible for intern rotation evaluations. Median scores on the pre- and post-module questions were compared using the Wilcoxon signed rank test for paired continuous variables with a non-parametric distribution, with p values < 0.05 considered statistically significant. Results were excluded pairwise for individual modules if students only completed either the pre- or post-module questions. SPSS Statistics Version 27 (IBM, Armonk, New York) was used for statistical analysis.

Feedback

Responses to anonymous survey questions developed and deployed using Qualtrics were recorded as percentage of interns selecting each response. Write-in responses were summarized, removing any identifying information and focusing on general themes. While we did not formally collect data on medical students who completed the modules as this was not part of our initial study design and therefore not covered under our IRB, we summarized anonymous feedback received from this group as part of routine course evaluations.

Results

Module utilization

The gastrointestinal pathology learning modules were first posted on the JHH internal pathology department education website on 9/20/2019. From that time until 12/31/2021, 12 of 28 anatomic pathology interns (43%) completed some or all of the learning modules, including 3 of 12 interns (25%) in the 2019–2020 class, 8 of 10 interns (80%) in the 2020–2021 class, and 1 of 6 interns (17%) in the 2021–2022 class. Of the 12 interns who chose to participate in the learning modules, 11 (92%) completed the esophagus module, 10 (83%) completed the stomach module, 9 (75%) completed the small bowel module, and 10 (83%) completed the colon module. While interns had access to the modules for the duration of the GI pathology rotation, and even outside of the rotation, most of those who participated chose to complete the modules during the first few days of the rotation.

Pathology intern assessment

Performance on the pre- and post-module assessment questions is shown in Fig. 3. A significant improvement in percentage of questions answered correctly for repeated pre-module and post-module questions was seen after completing the stomach module (p = 0.016), small bowel module (p = 0.015), and colon module (p = 0.040). Significant improvement was also seen between the overall pre- and post-module percentage of questions answered correctly for the stomach (p = 0.018), small bowel (p = 0.035), and colon (p = 0.029) modules. There was a trend toward improved performance after completing the esophageal module, but this was not statistically significant (p = 0.248 for repeated questions and p = 0.254 for overall percentage of questions answered correctly).

Pathology intern feedback

The post-module surveys were completed by 3–6 interns for each module (esophagus n = 6, stomach n = 5, small bowel n = 4, colon n = 3). The majority of interns self-reported that they spent between 16 and 60 min on each module. The amount of content covered was rated as “optimal” (as opposed to “not enough” or “too much”) for all of the modules. All interns rated the text, labeled histologic images, and post-
module assessment questions as either “very effective” or “extremely effective” for conveying information and applying the concepts taught in each module. 75%–100% of interns (varying based on the module) reported that they viewed the virtual slides included in the modules, and all those who viewed the virtual slides indicated that they were helpful. When asked about their likelihood of recommending the modules to their peers on a scale of 1–10, all respondents answered with 9 or 10 (classified as “promoters”). Survey responses are summarized in Fig. 4.

In the written feedback portion of the survey, interns indicated that they liked the level at which the material was taught and that assumptions were not made about baseline knowledge. One intern commented that parenthetical explanations included in the text were helpful for defining unfamiliar terms. Another commented “Wish we had these for all organ systems!” Gynecologic and head and neck pathology were suggested as topics for future modules. There were relatively few suggestions for improvement. One learner commented that “parakeratosis” should be defined in the esophagus module, while another suggested adding a discussion on microscopic colitis to the colon module. These changes were made to the modules after the conclusion of the study.

Medical student feedback

Forty-five medical students participated in the virtual surgical pathology elective and 8 additional medical students enrolled in the pre-clinical gastroenterology course completed the modules. Several medical students commented that they found the online learning modules useful and requested more modules covering additional topics. One student commented “The online learning modules for the GI system were super informative. I think it would be a tremendous resource to the department if those were made for every tissue”. Another medical student commented on the inclusion of annotated virtual slides in the modules, saying “I really liked the labeled virtual slides to point out what I am looking at”.

Discussion

Herein, we describe the successful design, development, and piloting of four online learning modules covering esophageal, gastric, small bowel, and colonic pathology. As our modules were geared toward pathology interns, we aimed to cover the pertinent features of commonly encountered diagnoses. Each module included text descriptions in bulleted-point form and labeled photomicrographs. While online modules similar to ours have been used before, one advance is our inclusion of links to annotated virtual slides. This allowed learners to view diagnostic findings in context, as they would for a clinical case. Our modules also incorporated pre- and post-module questions, which were designed to keep the learner engaged while applying the concepts from the modules. This feature also allowed us to assess baseline knowledge and learning.

Through our pilot study of several pathology intern classes at our institution, we demonstrated that the modules were effective for intern instruction and well-received. Interns who completed our modules showed a statistically significant improvement in performance between the pre- and post-module questions. While our question pool did not change between users, and therefore, we cannot exclude the possibility of interns sharing answers with each other, there was little incentive for interns to do this. As we did not have access to rotation evaluations for each intern under our IRB, we were unable to determine if completion of the modules correlated with clinical performance. Based on anonymous survey data, interns felt that the modules covered an appropriate amount of material and that each of the module components was beneficial. Furthermore, interns reported that they would recommend the modules to their peers and requested modules covering additional topics.

Although our pilot study was limited by a small sample size (12 interns), a large percentage of the interns in the 2020–2021 class participated, likely due to an increased focus on recruitment for our study during this time period. We noted that a lower percentage of interns chose to participate in the 2021–2022 class, likely due to the fact that some interns did not rotate on the GI pathology service during the study, as well as inconsistent efforts to recruit interns to participate in the modules at the beginning of this academic year. We also noticed a drop-off in survey completion, progressing from the esophagus to the colon module. Since there was not a corresponding decrease in module completion, we suspect that residents did not want to fill out the survey multiple times because the questions were the same between modules. Our pilot study was also limited by the lack of a control group, as the assessment questions and survey links were only provided within the modules. Although we did not survey those who chose not to participate, we suspect that time constraints and competing clinical and academic responsibilities may have been a factor.

While our modules were not initially designed for medical students, they proved to be an invaluable resource for medical student education during the COVID-19 pandemic. When in-person medical education was halted near the beginning of the pandemic, educators were left scrambling to develop high-quality virtual rotations for their students. Our learning modules were existing materials which were incorporated seamlessly into the virtual surgical pathology elective at JHH. The modules were included as a required component of the asynchronous curriculum, and could be accessed by students on their own schedules independent of location, personal responsibilities, and time zone—all challenges presented to virtual education during the pandemic. While we did not collect data on medical student performance on the modules as this was not part of our initial study design and therefore not covered under our IRB, we were able to review comments from anonymous course evaluations. Medical students enrolled in this course provided positive feedback on the modules, specifically requesting more modules
in future elective pathology and core preclinical courses. Based on this feedback, the modules were formally included as enhancement educational content in a core second-year medical student course.

Online learning modules such as ours have several beneficial aspects, including standardization of content and content delivery, flexible access to learning materials, and the lack of reliance on physical glass slides. However, we do not envision our modules replacing in-person instruction, which has the unique benefits of allowing for individualized feedback and development of mentoring relationships. We therefore envision our modules as a component of a flipped classroom approach, in which students independently review content in advance, allowing for application of the material and deeper discussions during teaching sessions.14,15

While pathology interns are not typically in a classroom setting, this approach could take the form of reviewing modules at the beginning of specific rotations, allowing for more focused slide previewing and a deeper discussion of cases during sign out. The GI pathology portion of our virtual surgical pathology rotation followed the flipped-classroom model, as students reviewed our modules and previewed clinical cases before an online, live teaching session with a gastrointestinal pathologist.11

One potential barrier to creating asynchronous educational content, including learning modules similar to ours, is the necessary time investment by educators. Our four learning modules were developed concurrently in a little over a year. One significant rate-limiting step was the creation of comprehensive slide sets for each module. Time to create the modules could be substantially reduced if high-quality glass or digital slide sets were available at the beginning of the process. Each step of the curriculum development process also required time, as we were determining the best way to present our material. We estimate that modules similar to ours could be created in about a month, provided that slide sets are available at the beginning of the project and the educator has a structured process to follow.

In closing, we hope that this description of our experiences can be used by others as a practical outline for designing, creating, and implementing online learning modules similar to ours. We aim to expand our modules to include additional subspecialty areas in surgical pathology. We also hope to reach a larger audience in the future, both within and outside of our institution.

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Declaration of competing interest

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References

1. Naritoku WY, Vasovic L, Steinberg JJ, Prystowsky MB, Powell SZ. Anatomic and clinical pathology boot camps: filling pathology-specific gaps in undergraduate

![Fig. 4. Summary of survey responses. The majority of interns completed the modules in 60 min or less (A) and viewed the virtual slides (B). All interns who completed the survey indicated that the module components were “very effective” or “extremely effective” (C) and that they were likely to recommend the modules to their peers (D).]
medical education. Arch Pathol Lab Med. 2014;138(3):316–321. doi:10.5858/arpa.2013-0356-SA.

2. Molavi DW. The Practice of Surgical Pathology: A Beginner’s Guide to the Diagnostic Process. Springer Science+Business Media LLC; 2008:48–74.

3. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of E-learning in medical education. Acad Med. 2006;81(3):207–212. doi:10.1097/00001888-200603000-00002.

4. Dee FR. Virtual microscopy in pathology education. Hum Pathol. 2009;40(8):1112–1121. doi:10.1016/j.humpath.2009.04.010.

5. Marsch AF, Espiritu B, Groth J, Hutchens KA. The effectiveness of annotated (vs. non-annotated) digital pathology slides as a teaching tool during dermatology and pathology residencies. J Cutan Pathol. 2014;41(6):513–518. doi:10.1111/j.cup.12328.

6. Van Es SL, Kumar RK, Pryor WM, Salisbury EL, Velan GM. Cytopathology whole slide images and adaptive tutorials for postgraduate pathology trainees: a randomized crossover trial. Hum Pathol. 2015;46(9):1297–1305. doi:10.1016/j.humpath.2015.05.009.

7. Samulski TD, La T, Wu RI. Adaptive eLearning modules for cytopathology education: a review and approach. Diagn Cytopathol. 2016;44(11):944–951. doi:10.1002/dc.23558.

8. Samulski TD, Taylor LA, La T, Mehr CR, McGrath CM, Wu RI. The utility of adaptive eLearning in cervical cytopathology education. Cancer Cytopathol. 2018;126(2):129–135. doi:10.1002/cncy.21942.

9. Perron E, Battistella M, Vergier B, et al. Online teaching of inflammatory skin pathology by a French-speaking International University Network. Diagn Pathol. 2014;9(suppl 1). doi:10.1186/1746-1596-9-S1-S5 (Suppl 1):S5.

10. Mills AM, Meyers-Needham M, LeGallo RD, et al. From slide sets to sound bites: teaching and learning pathology in the digital age. J Am Soc Cytopathol. 2014;3(4):183–187. doi:10.1016/j.jasc.2014.03.003.

11. White MJ, Birkness JE, Salimian KJ, et al. Continuing undergraduate pathology medical education in the coronavirus disease 2019 (COVID-19) global pandemic: the Johns Hopkins virtual surgical pathology clinical elective. Arch Pathol Lab Med. 2021;145(7):814–820. doi:10.5858/arpa.2020-0652-SA.

12. Genes to society: a curriculum for the Johns Hopkins University School of Medicine. Johns Hopkins Medicine. Accessed August 16, 2022. https://www.hopkinsmedicine.org/som/curriculum/genes_to_society/curriculum-overview.html.

13. Thomas PA, Kern DE, Hughes MT, et al. Curriculum Development for Medical Education: A Six-step Approach. Johns Hopkins University Press; 2016.

14. Hew KF, Lo CK. Flipped classroom improves student learning in health professions education: a meta-analysis. BMC Med Educ. 2018;18(1):38. doi:10.1186/s12909-018-1144-x.

15. French H, Arias-Shah A, Gisondo C, Gray MM. Perspectives: the flipped classroom in graduate medical education. NeoReviews. 2020;21(3):e150–e156. doi:10.1542/neo.21-3-e150.