Continuing Undergraduate Pathology Medical Education in the Coronavirus Disease 2019 (COVID-19) Global Pandemic

The Johns Hopkins Virtual Surgical Pathology Clinical Elective

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Context.—In the early months of the response to the coronavirus disease 2019 (COVID-19) pandemic, the Johns Hopkins University School of Medicine (JHUSOM) (Baltimore, Maryland) leadership reached out to faculty to develop and implement virtual clinical clerkships after all in-person medical student clinical experiences were suspended.

Objective.—To develop and implement a digital slide-based virtual surgical pathology (VSP) clinical elective to meet the demand for meaningful and robust virtual clinical electives in response to the temporary suspension of in-person clinical rotations at JHUSOM.

Design.—The VSP elective was modeled after the in-person surgical pathology elective to include virtual previewing and sign-out with standardized cases supplemented by synchronous and asynchronous pathology educational content.

Results.—Validation of existing Web communications technology and slide-scanning systems was performed by feasibility testing. Curriculum development included drafting of course objectives and syllabus, Blackboard course site design, electronic-lecture creation, communications with JHUSOM leadership, scheduling, and slide curation. Subjectively, the weekly schedule averaged 35 to 40 hours of asynchronous, synchronous, and independent content, approximately 10 to 11 hours of which were synchronous. As of February 2021, VSP has hosted 35 JHUSOM and 8 non-JHUSOM students, who have provided positive subjective and objective course feedback.

Conclusions.—The Johns Hopkins VSP elective provided meaningful clinical experience to 43 students in a time of immense online education need. Added benefits of implementing VSP included increased medical student exposure to pathology as a medical specialty and demonstration of how digital slides have the potential to improve standardization of the pathology clerkship curriculum.

Objectives for the Continuing Undergraduate Pathology Medical Education in the Coronavirus Disease 2019 (COVID-19) Global Pandemic

On March 10, 2020, Johns Hopkins University (Baltimore, Maryland) President Ronald J. Daniels announced the suspension of in-person classes for all students, with Johns Hopkins University and Johns Hopkins Medicine (Baltimore, Maryland) shortly thereafter implementing physical distancing and promoting telework when possible, in response to the coronavirus disease 2019 (COVID-19) outbreak in the United States. These decisions were made in an effort to protect the safety of students, patients, and health care providers in the rapidly evolving COVID-19 pandemic with innumerable unknowns, institution-specific staffing and infrastructural challenges to providing safe patient care,1–4 and global lack of resources in COVID-19 testing and personal protective equipment.

Thus, in the earliest weeks of the global COVID-19 pandemic, undergraduate medical education pivoted from close and intense in-person education and interactions to complete physical distancing and online learning. At Johns Hopkins University School of Medicine (JHUSOM), at maximum, there were approximately 360 medical students needing to progress their education in a virtual learning environment. Like educators across the world, JHUSOM leadership and faculty were faced with the overwhelming task of rapidly developing robust virtual clinical curricula within weeks to maintain educational contact with an incredible number of students.

In this setting, JHUSOM leadership actively reached out to faculty to develop and implement 2- or 3-week virtual clinical clerkship rotations. The Department of Pathology
sought to offer a virtual pathology elective to meet the new demand for virtual clinical instruction and ensure medical students had an opportunity to rotate in pathology in light of the new physical distancing guidelines. By March 20, a virtual surgical pathology (VSP) clinical elective was open for registration, with the first pilot rotation beginning on March 23.

Herein we describe our experience with developing and implementing a 3-week digital slide–based VSP clinical elective, one of the first virtual clinical electives offered at JHUSOM after the temporary suspension of in-person clinical rotations. Since implementation in March 2020, VSP has been offered 7 times as of February 2021 to a total of 43 students. Similar to the comprehensive remote anatomic pathology experience described by the University of Washington,5 the Johns Hopkins VSP clinical elective not only provides a meaningful clinical experience to students in a time of immense online education need, but effectively increases medical student exposure to pathology as a medical specialty and demonstrates how digital slides can standardize the pathology elective curriculum when it returns to an in-person format.

METHODS

To implement a robust and meaningful virtual experience that would rival an in-person surgical pathology (SP) elective, Kern’s 6-step approach to curriculum development for medical education6 was used to guide the planning of the VSP elective. In summary, our identified problem was how to provide a VSP experience. We then performed a targeted needs assessment, formulated VSP goals and objectives, and created educational strategies. Formal curriculum piloting, phasing in, and evaluation subsequently followed.

Targeted Needs Assessment

Review of the In-Person SP Elective.—To develop the VSP rotation, we first reviewed our prior rotation offerings to determine the needs for a virtual rotation. Course evaluations and medical student rotation data from the preceding 5-year period (2014–2019) were also obtained from the JHUSOM Office of the Registrar.

Pre–COVID-19, JHUSOM medical students had several options for in-person SP elective experiences. Senior medical students most frequently rotated on the 4-week outside slides (OS) SP consult service. The goals and objectives of this experience were to train students in general techniques of general SP, to support them in becoming responsible for the microscopic examination of their assigned cases, to facilitate their participation in all conference activities in the division, and to increase student awareness and understanding of the role played by SP in patient management.

While on OS, senior medical students were responsible for previewing a select number of complete outside cases for confirmation of diagnosis at Johns Hopkins Hospital, often weighted toward routine SP biopsies including breast, prostate, and gastrointestinal (GI) tissues. On average, students previewed 2 to 5 complete cases daily and were encouraged to render formal diagnoses. Cases selected for previewing were at the complete discretion of the students and residents on service based on student interests, and in general included the aforementioned routine SP biopsies and subsequent resections. Students were not required to keep a case log or maintain case write-ups for periodic formative feedback by faculty. Students were required to attend and present their cases at daily sign-out with the residents on service, which typically lasted 1 to 3 hours. Faculty rotated on the service 1 week at a time and provided teaching at the medical student and resident levels. Residents also provided teaching outside of sign-out, but education quality and quantity varied and was dependent on medical student interest and/or resident availability. In addition to previewing and sign-out, students were also expected to attend the daily SP quality assurance conference and all resident lectures and conferences and to deliver a 10-minute end-of-rotation presentation. Students were also given the opportunity to rotate on subspecialty services.

In addition to the OS rotation, students seeking more in-depth pathology exposure could select a combined autopsy and OS elective. This extended pathology elective experience allowed medical students to also complete a full autopsy, from evisceration to the final report.

Finally, students could elect to rotate on the gynecologic and obstetric pathology service as a 2-week selective within the core clerkship in women’s health rotation. While on the gynecologic and obstetric pathology selective, students were expected to participate in daily learning and patient care activities of the Division of Gynecology and Obstetrics Pathology, including previewing select cases, attending and participating in sign-out, participating in specimen grossing under the direct supervision of a pathology resident, and attending interdisciplinary conferences, including gynecologic tumor board and colposcopy clinic pathology conference.

Needs for a Virtual Pathology Learning Environment.—Existing slide-scanning capabilities and online resources were reviewed. Slides for use in unfunded educational projects could be digitized using Leica Aperio AT (Leica Biosystems Imaging, Inc, Buffalo Grove, Illinois) and Roche iScan HT (Roche Diagnostics International, Rotkreuz, Switzerland) scanners, and stored and served using Concentriq (Proscia) (Philadelphia, Pennsylvania), a system implemented and available pre–COVID-19. The medical school Scientific Foundations of Medicine (SPF) histology and pathology online learning modules available for use by all JHUSOM medical students were generated on an Open edX platform (Cambridge, Massachusetts), termed Inversus, served from a local Linux (San Francisco, California) server. Gross dissection videos created pre–COVID-19 were stored on YouTube (San Bruno, California) and offered through an internal trainee education Web page. Online GI pathology learning modules created by a senior pathology resident pre–COVID-19 using iSpring Suite 9 (Alexandria, Virginia) were similarly offered through an internal trainee education Web page.

Digital platforms available for use through JHUSOM were assessed for learner accessibility and potential applications in a virtual learning environment. Web-based communications (Zoom, Zoom Video Communications, Inc, San Jose, California; Microsoft Teams, Microsoft, Redmond, Washington; Skype, Microsoft) were subjectively evaluated for whole slide image resolution and quality and assessed by SP faculty and a pathology resident. The technology platforms and connections assessed were (1) laptop connected to home Wi-Fi network, (2) tablet connected to home Wi-Fi, and (3) mobile device on cellular network. Medical students at JHUSOM use Blackboard (Blackboard e-Education platform, Blackboard Inc, Washington, DC) throughout the preclinical curriculum, and Blackboard was therefore the most accessible learning management system for VSP.

All technology platforms and Internet connections demonstrated high fidelity for the whole slide image scanned at >X40, with minimal lag or pauses in Internet connectivity either when viewing digital slides individually (asynchronous previewing) or when viewing digital slides via shared screen (synchronous sign-out). Zoom demonstrated consistent image quality, and most users already had familiarity with the software.

VSP Goals and Objectives

In line with the perceived impact of the in-person OS elective and considering that students interested in specialties other than pathology may rotate on VSP, course objectives were designed to introduce students using a virtual learning environment to the role of SP in the delivery of multidisciplinary care with an emphasis on foundations of SP and clinical-pathologic correlation (Table 1).

Development of Educational Strategies

Virtual SP educational strategies were created rapidly between March 18, 2020, when we decided to offer a course, and March 23,
Virtual surgical pathology elective core asynchronous and synchronous course outline. A. A passing grade required attendance to all synchronous activities unless otherwise specified by the course director, completion of all previewing at least 1 hour prior to the start of sign-out, completion of all asynchronous content, and completion of the end-of-rotation presentation and assessment. Abbreviation: SFM, Scientific Foundations of Medicine. B. Per the Johns Hopkins University School of Medicine recommendations for virtual electives with students in different time zones, mandatory synchronous events were advised to begin after 11 AM eastern standard time.

| A. Asynchronous and Independent Content | B. Synchronous Content |
|-----------------------------------------|------------------------|
| Assigned case previewing for small group “sign-out” and associated reading assignments | Orientation |
| Review SFM foundation of histology e-Lectures, virtual slides, and quizzes for blood cells and 5 different stains, muscle, connective tissue, bone, and cartilage, epithelium 1, and epithelium 2 | “Sign-out” units |
| Four e-Lectures: “Review of neoplasia histology,” “Careers in pathology,” “Review of cancer grading and staging,” “How to evaluate a surgical resection specimen” | Medical student-specific slide-review sessions and lectures |
| Gastrointestinal pathology e-learning modules (colon, esophagus, small bowel, stomach) | Daily resident lectures and conferences |
| Viewing of 3 gross dissection videos (thyroid, gallbladder, ascending aorta) | Brief 10-minute presentation on any surgical pathology topic to be given on the last day of the rotation |

**Virtual Surgical Pathology Rotation**

2020, when the pilot course went live. Development of educational strategies in total required approximately 15 to 20 hours by the course director, including time for drafting of course objectives and syllabus, Blackboard site design, e-lecture development and recording, communications with JHUSOM leadership, scheduling, and slide curation. The synchronous and asynchronous curriculum was designed to emphasize SP case previewing and sign-out (Figure A and B).

**Creation of a Digital Slide Set Specific for Senior Medical Student Education.**—Glass slides from general SP cases were curated with the intent to introduce medical students to the clinical practice of SP using a systematic approach. Cases selected for scanning included a variety of nonneoplastic, developmental, and inflammatory processes, in addition to benign and malignant neoplasms. Faculty ensured that all pathologic entities included in the student slide sets were appropriately covered in commonly used medical student text resources to reinforce the preclinical curricular content. A total of 100 de-identified hematoxylin-eosin, immunohistochemical, and special stained slides were scanned at \( \times 40 \) (Leica Aperio AT and Roche iScan HT), and the images were stored on the Amazon Web Services cloud (Seattle, Washington). Digital slides could be accessed on the Johns Hopkins digital pathology slide repository powered by Proscia Concentriq version 2.2.4. Supplemental cases were selected from the preexisting Johns Hopkins Department of Pathology surgical pathology unknowns scanned slide repository (https://digital.pathology.johnshopkins.edu/repos/451).

**Using Online Communication Tools to Create a Virtual Medical Education Environment.**—After confirmation that a virtual learning environment was feasible, Zoom was selected as the primary conferencing communications technology. This decision was aided by an existing agreement whereby Johns Hopkins users are automatically pushed into a Health Insurance Portability and Accountability Act–compliant Zoom instance/account. Waiting rooms and passcodes were used to further enhance Zoom meeting security. Blackboard was used for asynchronous course communications, dissemination of required course materials, and administration of an end-of-rotation assessment.

**Asynchronous and Independent Curriculum Content.**—The asynchronous and independent curriculum was designed to gradually increase in complexity during the short virtual rotation. The content for the first week focused on a comprehensive review of basic histology. Students were first required to review basic histopathology e-lectures, virtual slides, and quizzes from the preexisting curriculum from the required first-year medical student course, SFM. The students were then required to complete 4 online GI pathology learning modules to introduce basic SP concepts and terminology. The SFM and GI learning module content was further supplemented by 4 e-lectures created specifically for the VSP elective, 3 gross dissection videos from resident curricula, and an online resource from *The Practice of Surgical Pathology: A Beginner’s Guide to the Diagnostic Process* by Diana Molavi. The four 45- to 60-minute e-lectures were recorded on PowerPoint (Microsoft) and emphasized the 4 course objectives and provided foundational SP knowledge required to preview cases. The e-lecture topics were as follows: (1) review of neoplasia histology, (2) careers in pathology, (3) review of cancer grading and staging, and (4) how to evaluate a surgical resection specimen.

The subsequent 2 weeks of the rotation were designed to provide a systematic case-based introduction to SP, distributed among 6 to 7 units consisting of independent previewing sessions and synchronous sign-out sessions. For each case, students were provided with link(s) to digital slide(s), a brief clinical vignette, any pertinent gross descriptions, question prompts to guide previewing, and required reading primarily from *The Practice of Surgical Pathology: A Beginner’s Guide to the Diagnostic Process.* The required reading assignments throughout the rotation were selected to provide specific foundational information required to approach the cases; however, the students were advised to also use the additional reading sources provided in the syllabus and the medical literature. All required suggested texts were accessible online through the JHUSOM Welch Medical library on the Johns Hopkins University intranet.

The 6 previewing and sign-out units were designed to progressively increase in case volume and complexity. The first 2
units included 3 GI biopsies and nonneoplastic processes in other anatomic sites such as endometriosis and intrathyroidal thymic tissue, and the final sessions culminated with a complete set of prostate biopsies and select slides (ie, primary tumor, resection margin[s], lymph nodes, and/or distant metastasis) from oncologic resections. Students were provided specific prompts to guide previewing and were required to render formal diagnoses, including pathologic staging information and margin status where appropriate (Table 2). The number of cases assigned per unit ranged from 3 to 5, and the total number of slides per unit progressively increased from 3 to 15 from the first to the last unit. Later units also included immunohistochemistry, special stains, and/or special studies such as electron microscopy (cardiovascular pathology unit).

Students were required to submit their formal case diagnoses by at least 1 hour prior to the start of the sign-out session to allow the sign-out faculty and/or residents to tailor their teaching points. Final diagnoses were not graded. Although students were required to submit their own assignments, virtual group previewing was encouraged to increase social interaction in a time of unprecedented social isolation.

In the event of asynchronous downtime between required synchronous events and after completion of asynchronous assignments, students were expected to work on developing their own assignments, virtual group previewing and were required to render formal diagnoses, including pathologic staging information and margin status where appropriate (Table 2). The number of cases assigned per unit ranged from 3 to 5, and the total number of slides per unit progressively increased from 3 to 15 from the first to the last unit. Later units also included immunohistochemistry, special stains, and/or special studies such as electron microscopy (cardiovascular pathology unit).

Table 2. Prompts to Guide Student Previewing and Minimum Previewing Expectations

| Question | Instructions |
|----------|-------------|
| 1. What tissue type(s) do you see? | Identify tissue type(s) |
| 2. What appears abnormal, and why? | Describe what appears abnormal and why |
| 3. Does the abnormality appear nonneoplastic (ie, inflammatory response, ectopic tissue, iatrogenic, developmental abnormality, etc) or neoplastic, and describe the histologic findings which helped you arrive at that conclusion | Identify whether abnormality is nonneoplastic or neoplastic and describe histologic findings |
| 4. If you feel the abnormality represents a neoplasm, attempt to determine the cell type of origin and if you feel it is benign or malignant | Attempt to determine cell type of origin and whether it is benign or malignant |
| 5. Differential diagnosis | List differential diagnoses |

Synchronous Curriculum Content.—The first synchronous activities were medical student–focused, virtual slide review sessions by faculty, including introductions to basic histopathology, cytopathology, and GI pathology. Then, the core of the synchronous curriculum was the 6 sign-out sessions, designed to be 2 to 2½ hours in duration. Sign-out faculty and/or residents were provided with the students’ final diagnoses, in addition to a teaching guide to ensure consistency with major teaching points. Students were also required to attend synchronous conferences and lectures, which had transitioned to a virtual format indefinitely because of COVID-19, including the daily SP quality assurance conference, with an opportunity for conference debriefing either immediately after the conference via Zoom or later via email; pathology departmental grand rounds; and resident anatomic and clinical pathology lectures and conferences. Additional suggested synchronous virtual activities included voluntary attendance at the weekly head and neck tumor board, daily virtual SP subspecialty sign-outs, and/or other virtual subspecialty quality assurance conferences. Virtual office hours were also offered as needed.

RESULTS

Curriculum Implementation

Faculty and resident volunteers were identified to assist with leading student sign-out units. Numerous formal opportunities for faculty development in education existed pre–COVID-19, available through either the JHUSOM Office of Faculty Development or the JHUSOM Institute for Excellence in Education. All faculty development sessions and courses were transitioned to a virtual format during COVID-19, which had the added benefit of increasing their availability to residents. Although virtual education courses were widely available and broadly encouraged, faculty and residents teaching in VSP were not required to participate given the rapidly evolving and increasing clinical and personal demands in the time of a pandemic. Resident volunteers were required to meet individually with the course director to formally review the cases they intended to teach in advance of their session. However, a senior faculty member was always scheduled to observe resident-led teaching to ensure consistency across rotations.

VSP Piloting and Phasing In.—On March 10, 2020, the Johns Hopkins Department of Pathology cancelled all in-person student and visiting resident electives at that time to allow for trainee and faculty physical distancing at sign-out and exploration of online communication technology. On March 17, JHUSOM formally announced the suspension of all medical student clinical experiences, which was further supported by a formal statement by the Association of American Medical Colleges stressing that it “strongly supports medical schools pausing all student clinical rotations, effective immediately, until at least March 31.”13 The rotation was piloted on an initial group of 4 medical students beginning March 23, and then successfully phased in to a larger group to meet the JHUSOM demand for online clinical education. The second, third, and fourth groups consisted of 19, 4, and 3 students, respectively, during the initial pilot period. Most students who took VSP were scheduled to graduate in either 2021 (24 of 43) or 2022 (18 of 43).

The course objectives, curriculum, expectations, and logistics, including how to access all online resources (digital slides, digital textbooks, e-lectures, GI learning modules, gross dissection videos, Blackboard) were formally reviewed with the students in an orientation session on the first day of the rotation. The implementation of the curriculum in the virtual space and in the midst of a global pandemic presented several novel, but typically minor, medical education challenges. The most significant novel challenge was differences in time zones for synchronous activities, as campus was closed to students and many had returned to their homes outside of Maryland. However, this was not unique to VSP and was addressed by JHUSOM, which requested that faculty begin synchronous virtual courses after 11:00 AM eastern standard time. Students in the second 2 rotations were in different time zones, including international zones; however, the impact was minimal. During this time frame, many resident lectures took place at noon to accommodate the incredible scheduling challenges for faculty and trainees during COVID-19.

Subjectively, the students reported on average 35 to 40 hours of work per week, categorized as synchronous instruction, asynchronous instruction, or independent...
work. On average, there were 10 to 11 hours per week of scheduled synchronous contact. The hours of asynchronous instruction (e-lectures, online SFM histology and pathobiology modules, and online GI learning modules) per week varied, with a maximum of 12 to 15 hours in week 1 because of the more time-intensive online SFM histology and pathobiology modules and online GI learning modules. Independent content accounted for approximately 20 hours per week, and consisted of 6 to 7 previewing units, required reading, presentation preparation, and the final assessment.

The core schedule and content remained fairly consistent with each VSP rotation, with only minor rotation-specific schedule adjustments dependent upon student and/or faculty availability and/or time zone considerations. The 19-student rotation required additional minor modifications, including end-of-rotation group versus individual presentations because of time limitations, sign-out occurring in 2 smaller groups versus 1, and weekly faculty office hours to enhance student engagement. The overall faculty time investment for curriculum development and implementation for the first 3 rotations was significant, estimated at approximately 50 to 60 hours for the course director and 10 to 20 for the course assistant director.

Course Use.—Between March 2020 and February 2021, 35 JHUSOM students and 8 non-JHUSOM students participated in the VSP rotation. In contrast, during the preceding 5 years (2014–2019), the number of participants in the in-person medical student SP rotations was a total of 24 JHUSOM students; there were only 2 or 3 students per year for the preceding 3 years (2017–2019).

Evaluation and Feedback

Student Evaluations.—The VSP elective was pass/fail, with a pass requiring attendance to all synchronous activities unless otherwise specified by the course director, completion of all previewing at least 1 hour prior to the start of sign-out, completion of all asynchronous content, and completion of the end-of-rotation presentation and assessment. Students were required to actively participate in all sign-out sessions, and were provided formative feedback throughout the course through active participation during sign-out and/or via email for incomplete pathologic diagnoses or staging. The end-of-rotation presentation research, conciseness, slide quality, efficacy, and delivery were semiquantitatively assessed using a standard student presentation rubric used on other JHUSOM clinical clerkships. The 10-question assessment was administered at the end of the rotation using Blackboard, and included hematoxylin–eosin slide images and multiple-choice questions. Explanations for questions answered incorrectly were released automatically to individual students through Blackboard after the entire group completed the assessment.

Summative grading was as follows: attendance to required lectures/conferences, emailing final diagnoses in weeks 2 and 3, and active participation in sign-out, 80%; completion of end-of-rotation presentation, 15%; assessment, 5%. All students received a final pass grade for VSP.

Course Evaluations.—Students were able to evaluate the course anonymously through the standard JHUSOM clinical clerkship course evaluation developed specifically for use in all virtual rotations at JHUSOM. On average, students provided positive objective feedback (Table 3). Positive subjective feedback highlighted (1) high level of faculty engagement, (2) appropriate balance of synchronous and asynchronous content, (3) ability to directly apply content learned in the preclinical undergraduate medical education curriculum when previewing, (4) medical student–specific teaching, (5) consistent formative feedback during sign-out, (6) faculty responsiveness, and (7) the benefit of required reading (one student noted, “We used a pathology textbook and had a lot of reading, but I think that helped us get a strong foundation and it made me realize I forgot the value of following a textbook.”). Constructive feedback highlighted (1) difficulties with understanding resident-specific lectures, (2) general issues pertaining to virtual courses (inability to visit laboratory facilities in person, limited opportunities for informal interaction with residents, and communication of course updates), (3) the value of medical students attending the daily SP quality assurance conference, (4) requests for more case previewing and sign-out sessions, (5) requests for additional medical student–specific lectures, (6) additional clinical correlation for previewed cases, and (7) additional review of basic histology.

Table 3. Summary of Objective Anonymous Student Feedback (N = 17) on a 5-Point Scale for the Virtual Surgical Pathology Elective From March 15, 2020, to June 30, 2020

| Question | Average | Minimum | Maximum | Mode | SD |
|----------|---------|---------|---------|------|----|
| I received clear learning objectives for the elective | 4.76 | 4 | 5 | 5 | 0.42 |
| My performance was assessed against the learning objectives | 4.82 | 4 | 5 | 5 | 0.38 |
| I had an opportunity to follow a variety of different patients | 4.43 | 3 | 5 | 5 | 0.73 |
| Faculty provided effective teaching throughout the elective | 4.76 | 4 | 5 | 5 | 0.42 |
| Residents provided effective teaching throughout the elective | 4.57 | 4 | 5 | 5 | 0.49 |
| I received effective, ongoing feedback throughout the elective | 4.38 | 3 | 5 | 5 | 0.70 |
| Faculty provided effective teaching throughout the online elective | 4.67 | 3 | 5 | 5 | 0.58 |
| I received effective, ongoing feedback throughout the online elective | 4.38 | 3 | 5 | 5 | 0.78 |
| In this distance learning course, technology was used to enhance my learning of the course objectives | 4.72 | 4 | 5 | 5 | 0.45 |
| Rate the quality of your educational experiences in this elective | 4.39 | 3 | 5 | 5 | 0.76 |

Formal comparison with prior in-person pathology rotation evaluations could not be performed because of the transition by JHUSOM to a course evaluation specific to virtual rotations. Additionally, there had not been a sufficient number of evaluations of the in-person pathology rotation compiled by the JHUSOM Office of the Registrar for release to the course director while maintaining student anonymity.
DISCUSSION

In the midst of a global pandemic, daily life and social experiences were halted abruptly, dramatically, and for the near future. However, in a time of incredible losses, the rapid and broad application of technology to help society adapt to our “new normal” has been a positive development. In SP, slide-scanning technology prior to COVID-19 had limited applications, primarily relating to remote diagnosis, regional and international consultation, peer review and quality assurance, primary frozen section review, and supplemental education. However, it was not until the global pandemic that pathologists were forced to broadly apply these technologies to provide pathology exposure to medical students, either those interested in pathology residency or those requiring virtual clinical experiences for graduation because of the temporary suspension of in-person activities. Our experience with VSP accomplished these goals and highlighted numerous opportunities for enhancing our in-person medical student SP experiences.

The use of digital slides allowed for greater standardization of the pathology clerkship curriculum, mirroring the clerkship curricular standardization in other medical specialties such as internal medicine, surgery, and obstetrics and gynecology. The benefits of a standardized pathology clerkship curriculum were 2-fold. First, students were exposed to the same cases, and the students’ case exposure and educational content was not dependent on the case distribution for that rotation. Second, and more importantly, standard cases allowed for more objective student assessment and substantive formative feedback. In the future, VSP course content will be further standardized and directly linked to pathology competencies for medical education, with an emphasis on organ system pathology and SP-specific diagnostic medicine and therapeutic pathology topics. Recognizing that the current VSP curriculum provides limited hands-on experience with gross dissection and autopsies, despite both being essential for pathology residents, either those interested in pathology residency or those requiring virtual clinical experiences for graduation because of the temporary suspension of in-person activities. Our experience with VSP accomplished these goals and highlighted numerous opportunities for enhancing our in-person medical student SP experiences.

A strength of this VSP model is the medical student–focused sign-out and slide review sessions with selected faculty members. The pre–COVID-19 medical student SP experience was often resident focused, because the elective consisted of medical students participating in the preexisting resident service/rotation; thus, on busy service days, coverage of medical student–level teaching points could be sacrificed for the sake of resident time management. Likewise, there were fewer medical student–specific lectures or slide review sessions. Compared with the in-person medical student SP experience in which the service attending changed weekly if not daily, VSP also provided closer and consistent one-on-one student–faculty interactions, allowing faculty to provide more meaningful formative student feedback.

However, a limitation of VSP is the relatively limited exposure the medical students have to current pathology residents. The lack of associated on-service residents with whom medical students could consult during previewing was a concern; however, in our experience, this surprisingly had minimal impact on the students’ ability to render a complete pathologic diagnosis after having been taught a stepwise approach and given minimum diagnostic expectations for case previewing. Nonetheless, we sought to overcome this limitation by teaching pathology residents to lead some of the medical student sign-out sessions. For the second and third rotations, 4 senior residents interested in education volunteered to lead sign-out sessions. Senior residents selected the cases from the medical student case list, and they reviewed the major teaching points with SP faculty in advance of the session. This had the dual effect of increasing medical student exposure to pathology residents and helping residents build competency in becoming expert diagnosticians with advanced medical knowledge and gross examination skills to meet Accreditation Council for Graduate Medical Education milestones.

Recognizing our new normal, and the innumerable unknowns of the COVID–19 pandemic, JHU SOM has sanctioned offerings of VSP through at least fall 2021. As more students continue to rotate, the cases will be refreshed to prevent dissemination of case information. However, the depth and breadth of content covered will remain consistent. Course evaluations have provided several actionable items, which will be addressed. Additional medical student slide–review sessions will be added to enhance the student experience, and the e-lectures may be delivered in person, if socially distanced space and faculty availability allow. The medical student rotators will also have access to a second digital basic histology slide set, with future plans for scanning a fetal digital basic histology set. Residents and fellows will also be given more opportunities to lead sign-out sessions, teach slide review sessions, and/or give medical student–specific lectures. Virtual office hours will continue to encourage student engagement and support student well-being, considering students are facing unique academic and personal challenges in the COVID–19 pandemic.

The most important lesson learned throughout this entire process is how technology and virtual learning increase equity in medical education. One immediate application of a virtual SP elective is to allow for visiting rotations. Even when visiting students are allowed to resume in-person electives, the option of a visiting rotation may still not be accessible to all students, particularly those underrepresented in medicine or from socioeconomically disadvantaged backgrounds, who on average have higher education debt. During the COVID–19 pandemic, VSP presents an opportunity to increase exposure to pathology in a time when in-person visiting rotations remain discouraged for the remainder of the 2020–2021 academic year and in-person electives for the 2021–2022 academic year may be limited. After the COVID–19 pandemic, VSP will present an opportunity to increase access to visiting rotations without requiring students to either procure further educational debt or obtain dedicated funding to subsidize their transportation and temporary housing. However, we recognize that not all institutions will have readily available resources such as slide scanning and online educational content such as gross dissection, learning modules, and online pathology textbooks, and thus the implementation of a VSP by programs with more limited resources may be challenging.

In closing, we hope this comprehensive description provides a practical outline of how to successfully develop and implement a slide-based VSP clinical curriculum. Surprisingly, we found VSP provided a more intensive, medical student–focused introduction to SP compared with our standard in-person medical student rotation on OS.
Virtual SP provided more consistent student expectations with consistent exposure to a diverse case set with increasing complexity. The additional, new asynchronous VSP content improved the medical student experience by providing a formal review of basic histology and basic concepts in SP prior to beginning case previewing. The many lessons learned in the development and implementation of VSP will be applied directly to our OS medical student rotation once we are able to safely return to an in-person format. However, we also emphasize that VSP presents an opportunity to provide equitable access to pathology visiting rotations. We therefore aim to continue this rotation in a virtual format, specifically for students underrepresented in medicine and from disadvantaged backgrounds, and encourage others to consider how they may do the same.

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References
1. Peros G, Gronki F, Molitor N, et al. Organizing a COVID-19 triage unit: a Swiss perspective. Emerg Microbes Infect. 2020;9(1):1506–1513.
2. In H, Muscarella P, Moran-Akin E, Michler RE, Melvin WS. Reflections on the coronavirus disease 2019 (COVID-19) epidemic: the first 30 days in one of New York’s largest academic departments of surgery. Surgery. 2020;168(2):212–214.
3. Aziz S, Arabi YM, Alhazzani W, et al. Managing ICU surge during the COVID-19 crisis: rapid guidelines. Intensive Care Med. 2020;46(7):1303–1325.
4. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72,314 cases from the Chinese Center for Disease Control and Prevention, JAMA. 2020;323(13):1239–1242.
5. Parker EU, Chang O, Koch L. Remote anatomic pathology medical student education in Washington State: an early COVID-19 experience. Am J Clin Pathol. 2020;154(5):585–591. https://doi.org/10.1093/ajcp/aqaa154
6. Thomas PA, Kern DE, Hughes MT, Chen BY. Curriculum Development for Medical Education: A Six-Step Approach. Baltimore, MD: Johns Hopkins University Press; 2016.
7. Robbins S, Kumar V, Cotran R. Robbins and Cotran Pathologic Basis of Disease. 8th ed. Philadelphia, PA: Saunders/Elsevier; 2010.
8. Bhusan V. First Aid for the USMLE Step 1. 3rd ed. New York, NY: McGraw-Hill, 2005.
9. Molavi DW. The Practice of Surgical Pathology: A Beginner’s Guide to the Diagnostic Process. New York, NY: Springer Science+Business Media LLC; 2008.
10. Rekhtman N, Bishop J. Quick Reference Handbook for Surgical Pathologists. Berlin, Germany: Springer-Verlag Berlin Heidelberg; 2011.
11. Young B, Stevens A, Lowe J, Wheater P. Wheater’s Functional Histology: A Text and Colour Atlas. 4th ed. Edinburgh, United Kingdom: Churchill Livingstone; 2000.
12. Lester SC. Manual of Surgical Pathology. 3rd ed. Philadelphia, PA: Saunders/Elsevier; 2010.
13. American Association of Medical Colleges. Important guidance for medical students on clinical rotations during the coronavirus (COVID-19) outbreak. March 17, 2020. https://www.aamc.org/news-insights/press-releases/important-guidance-medical-students-clinical-rotations-during-coronavirus-covid-19-outbreak. Accessed March 19, 2020.
14. Pantanowitz L, Sinard JH, Henricks WH, et al. Validating whole slide imaging for diagnostic purposes in pathology: guideline from the College of American Pathologists Pathology and Laboratory Quality Center. Arch Pathol Lab Med. 2013;137(12):1710–1722.
15. Saco A, Ramirez J, Rakislova N, Mira A, OrdJ. Validation of whole-slide imaging for histopathological diagnosis: current state. Pathobiology. 2016;83(2–3):89–99.
16. Evans AJ, Salama ME, Henricks WH, Pantanowitz L. Implementation of whole slide imaging for clinical purposes: issues to consider from the perspective of early adopters. Arch Pathol Lab Med. 2017;141(7):944–950.

17. Al Hafeeb A, Evans A, Ghazarian D. Virtual microscopy using whole-slide imaging as an enabler for teledermatopathology: a paired consultant validation study. J Pathol Inform. 2012;3:2.
18. Krenacs T, Zsakovics I, Diczhazi C, Ficsor L, Varga VS, Molnar B. The potential of digital microscopy in breast pathology. Pathol Oncol Res. 2009;15(1):53–58.
19. Wiemert S, Beil M, Saeger K, Hufnagl P, Schrader T. Integration and acceleration of virtual microscopy as the key to successful implementation into the routine diagnostic process. Diag Pathol. 2009;4:3.
20. O’Donnell BE, Choi H, Scialfa C. Combined robotic and nonrobotic telepathology as an integral service component of a geographically dispersed laboratory network. Hum Pathol. 2001;32(12):1300–1303.
21. Evans AJ, Chetty R, Clarke BA, et al. Primary frozen section diagnosis by remote microscopy and virtual slide telepathology: the University Health Network experience. Hum Pathol. 2009;40(8):1070–1081.
22. Leinweber B, Massone C, Kodama K, et al. Telepatholopathology: a controlled study about diagnostic validity and technical requirements for digital telepathology. Am J Dermatopathol. 2006;28(5):413–416.
23. Weinstein RS, Graham AR, Richter LC, et al. Overview of telepathology, virtual microscopy, and whole slide imaging: prospects for the future. Hum Pathol. 2009;40(8):1057–1069.
24. Jara-Lizaro AR, Thamppo FP, Teh M, Tan PH. Digital pathology: exploring its roles in diagnostic surgical pathology practice. Pathology. 2010;42(6):512–518.
25. López AM, Graham AR, Barker GP, et al. Virtual slide telepathology enables an innovative telehealth rapid breast care clinic. Hum Pathol. 2009;40(8):1082–1091.
26. Graham AR, Bhattacharyya AK, Scott KM, et al. Virtual slide telepathology for an academic teaching hospital surgical pathology quality assurance program. Hum Pathol. 2009;40(8):1129–1136.
27. Chong T, Palma-Diaz AM, O’Donnell BE, Fisher C, et al. The California Telepathology Service: UCLA’s experience in deploying a regional digital pathology subspecialty consultation network. J Pathol Inform. 2019;10:31.
28. Zhao C, Wu T, Ding X, et al. International telepathology consultation: three years’ experience between the University of Pittsburgh Medical Center and KingMed Diagnostics in China. J Pathol Inform. 2015;6:63.
29. Pantanowitz L, Wiley CA, Demetris A, et al. Experience with multimodality telepathology at the University of Pittsburgh Medical Center. J Pathol Inform. 2015;6:15.
30. Hanna MG, Reuter VE, Ardon O, et al. Validation of a digital pathology system including remote review during the COVID-19 pandemic. Mod Pathol. 2020;33(11):2115–2127.
31. Ahmad Z, Rahim S, Ud Din N, Ahmed A. Practice of academic surgical pathology during the COVID-19 pandemic: perspective on the situation during the lockdown from a leading center in Pakistan and reflections on the future—fears, hopes, and aspirations. Am J Clin Pathol. 2020;154(6):724–730. doi:10.1093/ajcp/aqaa158
32. Kwon R, Zhang ML, VandenBussche CJ. Considerations for remote learning in pathology during COVID-19 social distancing. Cancer Cytopathol. 2020;128(9):642–647.
33. Goroll AH, Morrison G, Bass EB, et al. Reforming the core clerkship in internal medicine: the SCIM/CDIM Project: Society of General Internal Medicine/Clerkship Directors in Internal Medicine. Ann Intern Med. 2001;134(1):30–37.
34. Jablonover RS, Blackman DJ, Bass EB, Morrison G, Goroll AH. Evaluation of a national curriculum reform effort for the medical core clerkship. J Gen Intern Med. 2000;15(7):484–491.
35. Knollmann-Ritschel BEC, Regula DP, Borowitz MJ, Conrad R, Prystowsky MB. Pathology competencies for medical education and educational cases. Acad Pathol. 2017;4:2374289517715040.
36. Hsieh CM, Nolan NJ. Confidence, knowledge, and skills at the beginning of residency: a survey of pathology residents. Am J Clin Pathol. 2015;143(1):11–17.
37. Vodovnik A, Aghdam MRF, Espejo DG. Remote autopsy services: a feasibility study on nine cases. J Telemed Telecare. 2018;24(7):460–464.
38. Vodovnik A, Aghdam MRF. Complete routine remote digital pathology services. J Pathol Inform. 2018;9:36.
39. McCluskey K, Katoke AE, Suo L, Mehta R. Interesting gross case workshop to remedy disconnect in surgical pathology curriculum. MedEdPORTAL. 2018;14:10724.
40. The pathology milestone project. J Grad Med Educ. 2014;6(1)(suppl 1):182–203. doi:10.4300/JGME-06-01s1-09
41. Dugger RA, El-Sayed AM, Dogra A, Messina C, Bronson R, Galea S. The color of debt: racial disparities in anticipated medical student debt in the United States. PLoS One. 2013;8(9):e74693.