



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.elsevier.com/locate/amjsurg

Original Research Article

The impact of the COVID-19 pandemic on medical student education: Implementation and outcome of a virtual general surgery curriculum

Nicole K. Zern^{a,*}, Laura A. Yale^b, Mark E. Whipple^b, Suzanne M. Allen^b, Douglas E. Wood^a, Roger P. Tatum^a, James D. Perkins^a, Kristine E. Calhoun^{a,b}

^a University of Washington, Department of Surgery, 1959 NE Pacific Street, Box 356410, Seattle, WA, 98195, USA

^b University of Washington School of Medicine, 1959 NE Pacific Street, A-300 Health Sciences Center, Box 356340, Seattle, WA, 98195, USA

ARTICLE INFO

Keywords:

COVID-19
Medical student education
General surgery clerkship
Virtual clerkship

ABSTRACT

Background: Due to the COVID-19 pandemic, medical schools were forced to adapt clinical curricula. The University of Washington School of Medicine created a hybrid in person and virtual general surgery clerkship.

Methods: The third year general surgery clerkship was modified to a 4-week in person and 2-week virtual clerkship to accommodate the same number of learners in less time. All students completed a survey to assess the impact of the virtual clerkship.

Results: The students preferred faculty lectures over national modules in the virtual clerkship. 58.6% indicated they would prefer the virtual component before the in-person experience. There was no change from previous years in final grades or clerkship exam scores after this hybrid curriculum.

Conclusions: If the need for a virtual general surgery curriculum arises again in the future, learners value this experience at the beginning of the clerkship and prefer faculty lectures over national modules.

1. Introduction

In early 2020, the Association of American Medical Colleges (AAMC) recommended that all US medical schools suspend in person instruction immediately due to the COVID-19 pandemic.¹ Certainly this had widespread impact on all facets of medical student education, but the effect on clinical rotations in procedure based specialties including general surgery was particularly significant. Given the urgency of the pandemic, third and fourth year medical students were immediately removed from clinical duties nationwide. The exodus of students from operating room settings allowed for preservation of personal protective equipment and protected students from exposure to the virus.

The University of Washington School of Medicine (UWSOM) offers a somewhat unique medical student experience in the five-state medical student education program, collectively known as WWAMI (Washington, Wyoming, Alaska, Montana and Idaho). WWAMI allows residents of these five states to attend UWSOM as an in-state student, completing the classroom phase of medical school in their home state and being allowed to complete clerkships at clinical training sites across the five state region. Given the multiple clinical training sites, changes to the medical student curriculum encompass a massive coordination across the five

states. Specifically for general surgery, there are 22 rotation sites: three University of Washington (UW) based hospital sites in Seattle, six non-UW sites in Seattle, and the remaining 13 sites located across the WWAMI region. Each site hosts between 1 and 6 third year students per third year rotation, which in the standard curriculum are six weeks long and run from end March/beginning April of each year. The six week length of the third year surgical clerkship is another uncommon facet of medical student education at UWSOM; the national average is 8 weeks² and many programs offer 12 weeks at the third year level.

As the COVID-19 pandemic progressed, there were two separate but pressing issues. The first dealt with students actively on rotations when the pandemic went into its first surge in March 2020. The timing of the COVID-19-mandated withdrawal of students from surgical clinical rotations at UW in March 2020 first impacted learners who had completed 4 of the 6 weeks of their rotation, and thus students were awarded a grade based on their performance to date. To earn their final clerkship grade, they were still required to complete the NBME shelf exam for the clerkship which was ultimately administered virtually, as cited in our initial description of the effects of COVID-19 on UW medical student surgical education published April 2, 2020.³

The next pressing issue became how and when to resume clinical

* Corresponding author. 1959 NE Pacific Street, Box 356410, Seattle, WA, 98195, USA.

E-mail addresses: Nicole.Zern@ValleyMed.org, nkzern@gmail.com (N.K. Zern), calhounk@uw.edu (K.E. Calhoun).

<https://doi.org/10.1016/j.amjsurg.2022.03.035>

Received 3 January 2022; Accepted 23 March 2022

Available online 26 March 2022

0002-9610/© 2022 Elsevier Inc. All rights reserved.

rotations during the ongoing pandemic. As the COVID-19 pandemic evolved and the first wave subsided, plans were made to allow medical students back into clinical rotations beginning June 29, 2020. Following the loss of the spring quarter which consisted of two 6-week rotation blocks for the third year clinical students, the difficult decision was made to maintain the planned academic calendar in order to avoid overlapping rotations with the next academic year and overwhelming the clinical sites with numbers of students. This decision meant that all of the third year students needed to complete their required clerkships over nine months rather than twelve, concluding as planned by March 2021. This paper describes how that was accomplished and lessons learned from what was implemented.

2. Methods

2.1. The creation of the virtual surgery clerkship

In order to fit 52 weeks of clinical instruction into 36 weeks, all rotations were shortened by two weeks each. Please see Fig. 1. There were significant concerns that decreasing an already short 6 week surgical clerkship would greatly deter educational goals, so the decision was made to maintain a 6 week structure for the general surgery rotation alone. Although there was a preference to have all 6 weeks as in person learning, several factors made this impossible. First, the number of students per rotation block would have needed to increase from 30 to 32 students to 40–45 to accommodate all students. This was not possible as clinical sites have a maximum student capacity, with most WWAMI-based sites taking 1–2 students and Seattle sites taking 2–6. Absorbing 10–15 additional students per rotation block would have diminished the educational value of sites already dealing with decreased elective case numbers due to the pandemic, worsened the very real issues with social distancing in hospital settings, and diluted the surgical exposure each student received. Given these multiple issues, the decision was made to have a 4 week on-site clinical rotation and a 2 week “virtual” clerkship to augment the in person experience. Secondary to logistical constraints to avoid overlap between 2 academic years, it was decided by UWSOM administration that students would complete their 4 week in person clerkship first, followed immediately by the 2 week virtual clerkship, and culminating in the NBME shelf exam to complete the rotation. This allowed each clinical site to maintain an appropriate number of learners with a new group of students starting the in person portion of the clerkship every 4 weeks.

The virtual clerkship was an innovative, multi-modality, coordinated effort designed to complement the in person portion of the clerkship. The virtual clerkship was intended to instruct students on a variety of surgical patient care topics. Topics were chosen from a pre-existing list of required patient encounters that each third year student on the Surgery clerkship is expected to observe during their clinical time, as well as other classic general surgery topics. The virtual clerkship was assembled from three components:

1. Virtual curriculum taught by UW Faculty via pre-recorded lectures. These were 1 h in length and covered the workup and management of a select general surgery topic, led by an expert faculty member. For the complete list of topics and faculty, please see Table 1 in the April 2020 paper.³
2. WiseMD Modules which are web-based and targeted for medical students learning surgery. (<https://aquifer.org/courses/wise-md/>)
3. Assigned reading from American College of Surgeons (ACS)/Association for Surgical Education (ASE) Medical Student Core Curriculum to correlate with assigned topics. (<https://www.facs.org/education/program/core-curriculum>)

Additionally, the virtual curriculum included a virtual suture lab live on Zoom and other live Zoom instructional sessions. The assigned virtual modules were intended for the students to complete at their preferred

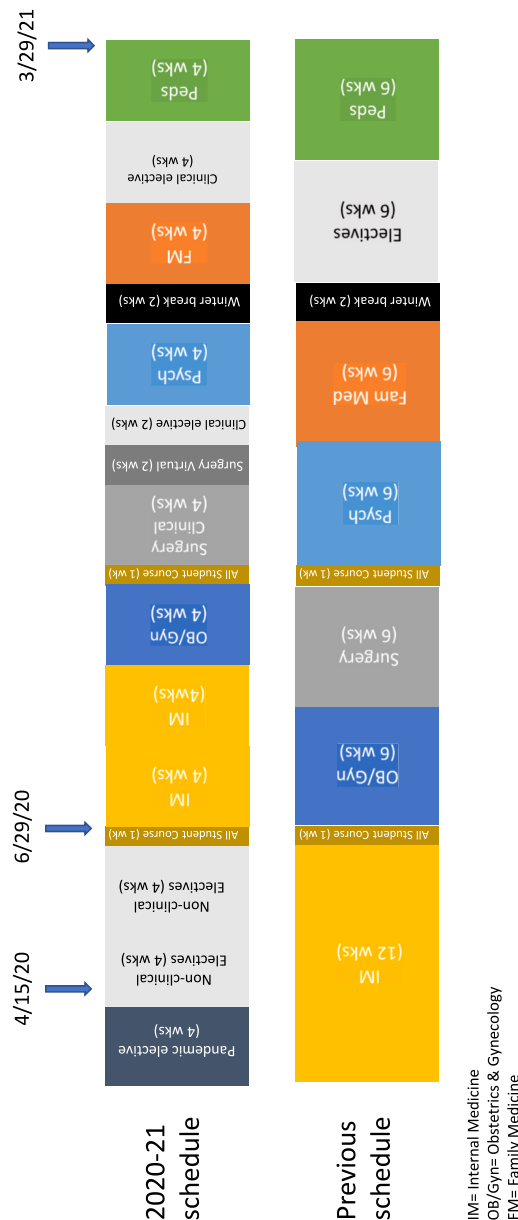


Fig. 1. 2020–2021 modified clerkship schedule.

pace over the 2 week period of the virtual clerkship. They were expected to complete all 10 “primary topic” modules, as well as 5 “secondary topic” modules of their choice. A simple quiz was completed at the conclusion of each module and was required for grade submission. In addition, to assess the quality of the hybrid clerkship, online evaluations were a required component of the virtual curriculum and expected to be completed by all 268 third year medical students who participated in the revised curriculum during academic year 2020–2021. The goal was to assess the value of the virtual clerkship including the recorded lectures, the WiseMD modules, and the ACS/ASE reading, as well as garner suggestions for improvement should a virtual option be needed again in the future.

As during the initial COVID-19-induced modifications to the third year clerkship, the NBME subject exam continued to be proctored and administered virtually at the end of the rotation. Despite consideration of switching to a Pass/Fail clerkship grading system for the year, the UWSOM elected to maintain the same grading structure as had been used pre-pandemic: Fail, Pass, High Pass, or Honors. On the Surgery clerkship, this overall grade is based primarily on clinical performance during the in person rotation, but a passing score on the subject exam is required to pass the clerkship as a whole and can influence the final grade if particularly high or low. Students were required to complete the virtual modules and the online evaluation as well to receive a final grade for the clerkship.

2.2. Statistical analysis

Continuous variables were given as mean and standard deviation. Categorical variables were presented as count and percentages. Student-t Test or Wilcoxon Rank-Sum Test, as appropriate for the distribution, was used to compare the continuous variables and Chi-square analysis for categorical variables. Significance was defined as $p < 0.05$. All analyses were conducted in JMP Pro Version 15 – Copyright 2019 SAS Institute Inc.

3. Results: evaluation of the virtual clerkship

The revised 6 week general surgery rotation was implemented with the return to clinical duties on June 29, 2020 and remained in place until the conclusion of the academic year in March 2021. All third year students participated in 4 weeks of in person clinical rotations on general surgical services at 1 of the 22 sites in the WWAMI network. They then completed 2 weeks of the virtual clerkship including the assigned modules, followed by the NBME subject exam at the conclusion of the 6 week rotation. Beginning with the new academic year in March 2021, third year students returned to the standard 6 week in person curriculum.

Despite apprehension regarding clerkship evaluation of performance due to the shortened in person experience, there was a trend toward improved final clerkship grades compared to the preceding 3 academic years, but not significant ($P = 0.091$). Overall, 48% of students attained an Honors grade, 42% High Pass, 10% Pass, and 1% Fail. Previous rates of Honors grades had been 39% (2017–18), 43% (2018–19), and 45% (2019–20).

There was also no significant difference in the NBME mean scores or ranges when comparing the 2020-21 year to the 3 prior academic years ($P = 0.68$, Table 1). No students in the required Surgery clerkship suffered a test failure during the 2020-21 academic year. This was not the case in several other of the required clerkships that decreased from 6 to 4 weeks and were without a supplemental virtual experience.

The overall attributes and value of the virtual clerkship as a whole were assessed using a six point Likert scale obtained from the evaluations completed by each student. Secondly, a five point Likert scale was

used to assess the individual virtual clerkship components to determine which were most valuable to the students (Table 2). The majority of students acknowledged value in the virtual curriculum, with >80% of the students recognizing the content as good/very good/excellent. The faculty lectures were favored by the students. For example, 225/268 students scored the faculty lectures helpful to extremely helpful (84.0%) compared to WiseMD 101/268 (37.7%) and ACS/ASE 109/268 (40.7%) ($P < 0.001$).

Common themes in comments on the educational content included noting redundancy in the WiseMD and ACS/ASE modules with the information presented in the faculty lectures, and issues regarding the length of materials in the national modules. It was disheartening to discover that a portion of students saw the virtual clerkship as a distraction that took them away from studying for the NBME exam or complained that the virtual clerkship was not specifically designed to help the students pass the NBME exam. However, many students anecdotally recognized the value of the two week “study period” that the virtual curriculum provided immediately in advance of the NBME exam.

When specifically queried as to the logistics of the in person 4 week clinical rotation first followed by the 2 week virtual curriculum, results were mixed (Fig. 2). Overall, 12% felt the order didn’t matter, while the majority (58.6%) would have preferred the virtual curriculum first. Predominant themes in the comments from the rotation evaluations were: “I feel like I learned a lot on the virtual clerkship that would have been useful to know during the clinical [time]” and “I would have felt more confident going into the clerkship [if the virtual curriculum was first]”. Conversely 29.5% of students preferred the order as it was executed, with the in person rotation first followed by the virtual period. Overwhelmingly this was related to the dedicated time to study just prior to the subject exam afforded by the virtual curriculum, with the predominant theme being: “I really needed extra time to study for the shelf [subject exam] - having the virtual clerkship second gave me more hours in the day to study compared to being on the in person clerkship”.

Despite the many negative comments generated by students regarding the virtual clerkship, such as describing it as “busy work” and “useless work that detracted from [their] ability to study for the NBME test,” individual module Likert ratings were high. Overall, when asked if the virtual curriculum was helpful, answers ranged from 92 to 99% affirmative. When broken down into components, faculty lectures were universally rated higher than the national modules, albeit with small percentage differences. When asked if the individual components “contributed to [their] understanding of topic X,” 94.5% of the students answered “yes” for the recorded lectures, 86.4% answered “yes” for the WiseMD modules, and 89% answered “yes” for the ACS curriculum reading ($P < 0.001$) (Table 3).

The quality of the UW faculty lectures is further demonstrated by the high metrics they received from students regarding their content, as well as their delivery. Lecture content was overwhelmingly rated as good (4) or excellent (5), with 84–96.5% of lectures rated in one of these two categories. Only 0.5–1% of students indicated that the lecture content was poor. Lecture delivery was similarly highly rated, with good or excellent metrics picked by students 78–95.5% of the time. A common theme observed throughout the comments was: “All of the lectures were fantastic, thank you for putting these together.”

Table 1
Surgical NBME exam scores.

Academic Year	Mean NBME Score	Range NBME scores
2020–21	74.7	52–92
2019–20	74	48–92
2018–19	74	55–91
2017–18	75.5	50–90

Table 2
Virtual curriculum evaluation scores.

	Mean (min 1-max 6)	Very Poor % (n)	Poor % (n)	Fair % (n)	Good % (n)	Very Good % (n)	Excellent % (n)
Please rate the virtual clerkship on the following:							
1. Course organization	4.64	0.37 (1)	2.61 (7)	10.07 (27)	30.22 (81)	33.21 (89)	23.51 (63)
2. Relevance of content	4.46	1.87 (5)	4.10 (11)	11.57 (31)	31.72 (85)	30.60 (82)	20.15 (54)
3. Reasonableness of assigned work	4.44	1.49 (4)	3.73 (10)	14.93 (40)	30.60 (82)	27.61 (74)	21.64 (58)
4. Clarity of requirements	4.60	0.75 (2)	3.36 (9)	12.69 (34)	27.24 (73)	30.60 (82)	25.37 (68)
5. Overall score	4.13	2.24 (6)	4.85 (13)	19.40 (52)	36.19 (97)	25.75 (69)	11.57 (31)
6. Overall contribution clerkship	3.94	2.61 (7)	9.70 (26)	25.37 (68)	28.36 (76)	20.90 (56)	13.06 (35)
	Mean (min 1-max 5)	Not applicable % (n)	Not at all helpful % (n)	Slightly helpful % (n)	Moderately helpful % (n)	Very helpful % (n)	Extremely helpful % (n)
How helpful were the following to your understanding of topics in the virtual clerkship?							
1. Recorded lectures	3.47	0.37 (1)	2.61 (7)	13.06 (35)	35.82 (96)	31.34 (84)	16.79 (45)
2. Wise MD modules	2.99	0.37 (1)	10.07 (27)	27.24 (73)	26.49 (71)	25.00 (67)	10.82 (29)
3. ACS/ASE curriculum	2.79	0.37 (1)	11.94 (32)	28.36 (76)	33.96 (91)	19.40 (52)	5.97 (16)
4. Virtual skills lab	2.58	10.82 (29)	19.40 (52)	26.12 (70)	23.88 (64)	12.31 (33)	7.46 (20)
5. Live Zoom sessions	3.12	5.97 (16)	6.34 (17)	22.39 (60)	29.48 (79)	25.00 (67)	10.82 (29)

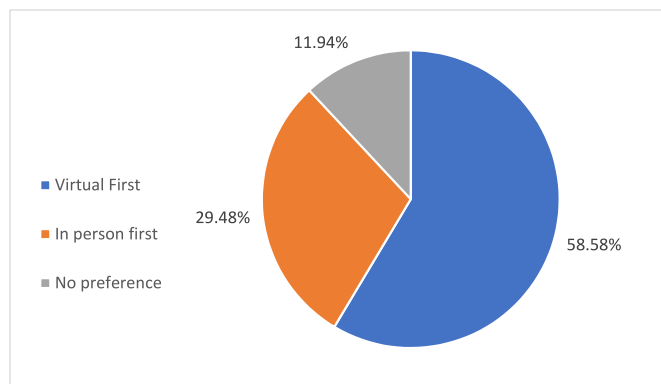


Fig. 2. Virtual clerkship component order preference.

Table 3
Comparison of Virtual Curriculum components' contribution to overall understanding.

Component	Total Response	Yes Contributed	%
Faculty Lectures	6221	5878	94.5%
WiseMD	4975	4298	86.4%
ACS Curriculum	4568	4065	89%

4. Discussion

4.1. Lessons learned: virtual general surgery medical student education

Given that the COVID-19 pandemic continues worldwide as of the writing of this report, it is certainly possible that medical schools will again be forced to limit in person learning opportunities. This remains especially detrimental to the procedural-based specialties like general surgery. To make the best educational experience possible for the third year medical students under a time crunch imposed by the urgency of the pandemic, a hybrid in person and virtual general surgery curriculum was implemented from June 2020–March 2021 at the University of Washington School of Medicine. After assessing survey results from 268 third year students who completed this curriculum, a virtual curriculum was not found to be an adequate substitute for clinical in person learning for general surgery. While students graciously acknowledged many positive components of this virtual curriculum, the overwhelming sentiment was that in person patient-based learning is the most effective means of learning general surgery. If virtual general surgery learning

becomes imperative once again, the majority of students would prefer the virtual segment be delivered *before* the in person experience in order to enhance knowledge base and allow preparation for real time surgical experiences. Furthermore, any instruction on surgical technique like a suture lab should be at the beginning of the clerkship prior to in person learning to optimize the utility of the skills taught. This feedback has been taken to heart - while there has been continuation of a virtual suture skills lab in the current academic year, it is given during the first week of the rotation, with more favorable feedback from students overall.

One innovative idea utilized to adapt to pandemic restrictions on in person learning at Emory University was a 2 week virtual medical student elective as an introduction to general surgery, prior to the in person clerkship. This was enacted during the initial months of the pandemic when medical students were prohibited from in person learning. This virtual curriculum outlined by Grady et al.⁴ incorporated both a suture lab as well as didactic learning, using fourth year students and faculty as instructors. Once COVID related restrictions on in person instruction were lifted, they returned to a standard in person surgical clerkship curriculum and did not continue the virtual format.

One feature that the implementation of our hybrid curriculum has highlighted is the value that students place on dedicated time to study in preparation for the NBME subject exam. Such study time may become even more critical as USMLE Step 1 moves to a Pass/Fail grading system, shifting more importance to NBME scores, clinical clerkship grades and Step 2 scores. Certainly 2 weeks of a self-directed virtual curriculum affords many opportunities to study for the exam, but as there is a shift back to a 6 week in person clinical rotation, students will need to preserve time near the end of the clerkship to dedicate to personal study. Interestingly, despite seemingly “more” time to study, the NBME scores did not change over this academic year compared to the past, but it did seem to protect students on Surgery from the increased risk of test failure seen in many of the other required clerkships that went from 6 to 4 weeks and did not have a virtual curriculum. This lack of significant change in NBME scores is mirrored in data from other institutions nationally including Columbia University.⁵ However, in their analysis of the impact of the COVID pandemic on medical student assessment, there were improved clerkship grades during the COVID period compared to historical controls. UWSOM showed this same trend with increased number of honors grades awarded compared to previous years. Reasons for this are not entirely clear at this point, but perhaps stem from changes to medical student life outside the classroom such as less travel and other activities, thus allowing more time to study.

There is likely a happy medium between 2 weeks of dedicated study and working clinically until the day of the exam, which may be afforded

by 1–2 days of dedicated study time prior to the shelf exam. This would potentially allow students to feel more prepared but not detract from the recognized value of the in person clinical rotation by shortening it significantly. This could be more easily implemented in other programs nationwide with longer general surgical clerkships, to not detract from the clinical experience. Given the already short 6 week experience at UWSOM, missing even 1–2 days could dilute the clinical experience, but it is a concept that may require consideration by administration if test failures are seen with increased frequency upon a return to the 6 week in person format.

Our learners favored faculty-led didactic education, whether recorded or live, on general surgery topics over prepared national modules for a myriad of reasons including brevity. Based on this feedback, the lectures recorded for the virtual clerkship have continued to be utilized as a part of the in person curriculum. Over the course of the 6 week rotation, students are asked to watch 1 recorded lecture per primary topic, while the secondary topic lectures, WiseMD modules and ACS/ASE modules are made available to them throughout the clerkship for self-study if desired. It remains impossible with any medium to cover the entire breadth of general surgery and subspecialty topics. This was recognized by our learners in that we did not include modules on orthopedic surgery, neurosurgery or otolaryngology, despite these topics still being tested on the subject exam. Given limited time constraints, these areas of surgery are unlikely to become a component of a general surgery-focused virtual curriculum in the future just as they are similarly not a component of traditional in person clerkships.

Another avenue for virtual surgical learning employed by many residencies during the COVID pandemic is the utilization of surgical videos as a substitute for in person learning in the operating room.⁶ These have been utilized both in the virtual group setting but also as an individual study tool for surgical residents. Surgical videos were not incorporated into the virtual medical student curriculum as a stand-alone entity, although many of the recorded faculty lectures utilized video clips to illustrate intraoperative teaching concepts. Given the goals of the third year medical student curriculum, focused intraoperative teaching with surgical videos was deemed less valuable than didactic based teaching. However this could be something to consider incorporating in the future, especially if virtual curricula are developed and tailored to the fourth year student planning a career in a surgical specialty.

Finally, comments from students illustrated a significant need for increased transparency and communication that has been brought to the forefront in many areas due to the COVID pandemic. Although UWSOM made efforts to explain why the virtual portion needed to be after, not before, the in person section due to enrollment/calendar logistics, it was apparent that students either did not hear or did not remember this explanation. They further did not seemingly understand why the Surgery clerkship could not accommodate students for 6 weeks all in person. Although efforts were made to explain the increased number of students each site would have to take to make this work, especially

during times when workspace social distancing was problematic and decreased elective surgical case numbers were occurring, this explanation also was lost to students. In the end, the quality of the in person educational experience was chosen over the quantity, making the best of a very difficult and unprecedented situation.

5. Conclusions

Medical student education, as with many other facets of education in the United States, has had to adapt and restructure to accommodate to constraints created by the COVID-19 pandemic. To continue to provide a robust general surgery clinical rotation despite many barriers, the University of Washington School of Medicine Surgery clerkship offered a hybrid in person and virtual curriculum for third year medical students. Overwhelmingly, students recognized some merits of the virtual curriculum while simultaneously identifying areas where it failed. Many lessons were learned from this valuable feedback that will allow us to refine our virtual curriculum should the need arise yet again to reduce in person presence on clinical rotations in general surgery.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

Dr Calhoun receives royalties from Up to Date. Otherwise there are no COI.

Acknowledgements

None.

References

1. AAMC announcement. *Important Guidance for Medical Students on Clinical Rotations during the Coronavirus (COVID-19) Outbreak*. March 17, 2020.
2. AAMC: Time required per clerkship. <https://www.aamc.org/data-reports/curriculum-reports/interactive-data/clerkship-week-requirements-curriculum-year>. Accessed 12/6/2021.
3. Calhoun KE, Yale LA, Whipple ME, et al. The impact of COVID-19 on medical student surgical education: implementing extreme pandemic response measures in a widely distributed surgical clerkship experience. *Am J Surg*. 2020;220:44–47. <https://doi.org/10.1016/j.amjsurg.2020.04.024>.
4. Grady ZJ, Gallo LK, Lin HK, et al. From the operating room to online: medical student surgery education in the time of COVID-19. *J Surg Res*. 2021;270:145–150. <https://doi.org/10.1016/j.jss.2021.08.020>.
5. Prigoff J, Hunter M, Nowygrod R. Medical student assessment in the time of COVID-19. *J Surg Educ*. 2021;78(2):370–374. <https://doi.org/10.1016/j.jsurg.2020.07.040>.
6. Chick RC, Clifton GT, Peace KM, et al. Using technology to maintain the education of residents during the COVID-19 pandemic. *J Surg Educ*. 2020;77(4):729–732. <https://doi.org/10.1016/j.jsurg.2020.03.018>.