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Opportunities for Radiology Trainee Education Amid the COVID-19 Pandemic: Lessons From an Academic Breast Imaging Program

Gary X. Wang, MD, PhD, Shinn-Huey S. Chou, MD, Leslie R. Lamb, MD, Anand K. Narayan, MD, PhD, Brian N. Dontchos, MD, Constance D. Lehman, MD, PhD, Randy C. Miles, MD, MPH

The COVID-19 pandemic required restructuring of Radiology trainee education across US institutions. While reduced clinical imaging volume and mandates to maintain physical distancing presented new challenges to traditional medical education during this period, new opportunities developed to support our division in providing high-quality training for residents and fellows. The Accreditation Council for Graduate Medical Education (ACGME) Core Competencies for Diagnostic Radiology helped guide division leadership in restructuring and reframing breast imaging education during this time of drastic change and persistent uncertainty. Here, we reflect on the educational challenges and opportunities faced by our academic breast imaging division during the height of the COVID-19 pandemic across each of the ACGME Core Competencies. We also discuss how systems and processes developed out of necessity during the first peak of the pandemic may continue to support radiology training during phased reopening and beyond.

Key Words: COVID-19; Breast Imaging Fellowship; Radiology Residency; Medical Training.

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INTRODUCTION

Challenges posed by the COVID-19 pandemic required restructuring of radiology training programs across US institutions (1,2). Medical training has traditionally relied on experiential learning gained through the performance of clinical work under attending supervision. While reduced clinical imaging volume and mandates to maintain physical distancing have presented challenges to traditional medical education, opportunities have arisen to develop new methods for effective training based on existing educational frameworks (1).

During the height of the pandemic, the American College of Radiology and American Society of Breast Surgeons recommended nationwide deferment of mammography screening examinations (3). Weekly mammography volumes decreased by over 90% nationwide compared to pre-COVID levels (4,5). Consequently, the same spectrum of educational challenges

broadly confronted by all radiology training programs were not only present but magnified for breast imaging. In turn, an understanding of the challenges, solutions, and opportunities encountered in breast imaging training may serve as a useful case study for radiology educators from all subspecialties.

The Accreditation Council for Graduate Medical Education (ACGME) Core Competencies for Diagnostic Radiology can help guide educators in restructuring and reframing radiology training during this time of ongoing change and uncertainty (Table 1) (6). Here, we reflect upon educational challenges and opportunities faced by our program during the COVID-19 pandemic, which may serve as a case study for programs from all subspecialties. This discussion will be structured using the ACGME Core Competencies framework to better help educators extend and adapt lessons learned to their own programs. We will explore in detail the challenges and opportunities for continued growth across the Core Competency domains (Table 2). We will also discuss how systems and processes developed out of necessity during the first peak of the pandemic may continue to support radiology training during phased reopening and beyond.

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From the Department of Radiology, Massachusetts General Hospital, 55 Fruit Street, Boston, MA 02114-2696. Received August 9, 2020; revised September 15, 2020; accepted September 21, 2020. **Address correspondence to:** R.C.M. e-mails: rmiles@partners.org, randy_miles@msn.com

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SYSTEMS-BASED PRACTICE

This core competency covers patient safety, quality assurance and improvement, and patient care coordination. The

TABLE 1. ACGME Core Competencies for Diagnostic Radiology

ACGME Core Competency	Subdomain	Examples of Expert-Level Trainee Activities and Qualities
Systems-based practice	Patient safety	Helps improve processes that guard against patient safety events
	Contrast, radiation, MR safety	Helps lead efforts to promote contrast, radiation, and MR safety
	Quality improvement	Creates, implements, and assesses quality improvement initiatives
	Patient-centered care	<ul style="list-style-type: none"> Helps design and implement care coordination processes
	Physician leadership	<ul style="list-style-type: none"> Leads efforts to promote health equity Leads efforts to enhance high-value, efficient, effective care Participates in health policy advocacy
	Informatics	Engages in using informatics to guide radiology operations
Interpersonal & communication skills	Patient-/family-centered communication	Actively minimizes and helps others minimize communication barriers and conduct shared decision making
	Interprofessional and team communication	Role models flexible communication strategies that value input from all health care team members
	Communication within health care systems	Facilitates dialogue on systems issues among community stakeholders
Patient care	Reporting	Reports are tailored to meet subspecialty needs
	Clinical consultation Image interpretation	Provides subspecialist-level consultations Interprets with subspecialist-level expertise and efficiency
Medical knowledge	Procedure competence	Independently performs subspecialty procedures
	Diagnostic knowledge	Formulates diagnoses at a subspecialty level by integrating knowledge of anatomic and molecular imaging with pathophysiology
	Physics	Applies and teaches physics principles for optimization of image quality
	Protocol selection Imaging technology	Can adapt and develop imaging protocols Performs and publishes research on imaging technology
Practice-based learning and improvement	Evidence-based practice	Critically appraises and helps other critically appraise and apply evidence for patient care
	Reflective practice and professional growth	<ul style="list-style-type: none"> Seeks and helps others seek feedback on performance
Professionalism	Professional behavior and ethics	<ul style="list-style-type: none"> Designs and implements learning plans for self, others Demonstrates professionalism and coaches others when behaviors fall below professional expectations Identifies and addresses systemic factors that may cause or exacerbate ethical issues
	Accountability and conscientiousness Self-awareness and help seeking	Takes personal ownership of systems-level outcomes <ul style="list-style-type: none"> Optimizes personal and professional well-being Coaches others when emotional responses or knowledge/skill limitations do not meet expectations

development and implementation of unprecedented measures to mitigate risk and maintain healthcare system capacity in the face of the pandemic provided our fellows with invaluable lessons, as they were central in implementation of risk mitigation measures.

Prior to the pandemic, our division readily accommodated five fellows and up to four residents. Fellows and residents were assigned to a primary role each day including: screening mammography, diagnostic clinic (mammography/ultrasound), MRI, biopsy/aspiration, needle localization, and

TABLE 2. Challenges and Opportunities to Support Continued Growth of Trainees Along ACGME Core Competencies in the COVID-Era

ACGME Core Competency	Pre-COVID Opportunities for Fellows to Improve Core Competency	COVID-Era Challenges	COVID-Era Opportunities to Continue Advancing Along Core Competency
Systems-based practice	Engagement with QA/QI activities Clinical work as part of multidisciplinary oncology teams	Reduced volume of imaging and procedures Reduced volume of interactions with patients and health-care workers	Engagement with numerous QA/QI and risk mitigation activities to support COVID-era needs
Interpersonal & communication skills	Clinical interactions with patients and healthcare workers including technologists and referrers	Reduced opportunities to provide care coordination Altered norms of interpersonal interactions, educational conferences, and workstation-based teaching to support risk mitigation measures	Constantly changing conditions and altered communication norms drove growth in this domain
Patient care	Screening mammography and MRI Diagnostic imaging Procedures (biopsies and needle localizations)		Risk mitigation measures allow continued engagement with imaging and procedures Remote work tools enable dissemination of remaining clinical learning opportunities
Medical knowledge	Teaching files and textbooks Workstation-based education ("read outs") In-person educational conferences Radiology-pathology conferences Engagement with divisional research efforts		Remote work solutions enable conferences to continue and to be more widely available Remote work solutions allowed research activities to continue from home
Practice-based learning and improvement	Daily engagement in patient management and collaborative decision-making opportunities Daily opportunity to assess personal clinical performance		Remote work solutions enable dissemination of clinical management and decision-making learning points Process of adapting to COVID-related needs allow new opportunities for self-reflection
Professionalism	Educational conferences and research projects on improving healthcare access and outcome Learning from role models while performing clinical work		New opportunities to further build this skillset through addressing additional COVID-era patient needs Learn new ways to be professional while working and interacting remotely

second opinion consultation on outside facility imaging. Trainees interpreted imaging studies, performed ultrasound examinations, drafted preliminary reports, and performed mammogram-, ultrasound-, and MRI-guided procedures under attending supervision. Readouts, attending review of cases after trainee evaluation, were performed in person with the attending and trainee seated next to each other.

Starting in March 2020, when the first cases of COVID-19 were identified in our state, clinical schedules were promptly modified in response to deferment of screening mammography and MRI examinations to respond to risk mitigation measures and declining volumes. In support of institutional guidelines to limit in-hospital personnel to those essential for clinical care, one attending and fellow were each assigned to work on-site each day. A reserve attending and fellow staff

were also assigned each day, who could also cover clinical duties based on changes in clinical volumes until the peak of the pandemic. A step-wise process of incrementally increasing attending and fellow coverage was then enacted, as volumes began to increase following the peak of the pandemic.

To support risk mitigation measures in the setting of low clinical volumes, residents previously scheduled for breast imaging rotations were placed into a residency-wide pool of off-site residents from March to June. These residents were taught through a comprehensive virtual curriculum covering topics across radiology managed by the residency leadership. While all senior residents had already fulfilled ACGME breast imaging requirements prior to implementation of the virtual curriculum, the schedule for the next academic year (2020-2021) was constructed to ensure remaining junior residents

fulfilled their required 12 weeks of clinical breast imaging rotations prior to graduation.

To support physical distancing measures, the on-site fellow and attending were separated into different reading rooms and used telecommunication tools to review imaging together. Telecommunication tools were also used to navigate patients throughout the clinic, while communicating with technologists and administrative staff. Use of these resources also helped to eliminate the need to transfer paperwork between patients, physicians, and ancillary staff for all phases of care.

Fellows participated in the implementation of new clinical workflows designed to limit the number of personnel present for hand-held ultrasound exams and procedures to the absolute minimum necessary. For example, ultrasound-guided procedures previously involved a technologist operating the ultrasound unit, while the fellow performed the procedure under direct attending supervision. This was adjusted to require only the presence of a fellow and an attending. These workflows were efficient and feasible during our fellows last quarter of training before proceeding to independent practice. When communicating results or reviewing procedural issues in person, only one provider was present to further support risk mitigation measures.

Same day care was instituted for all examinations. Biopsies and aspirations were performed on the same day as diagnostic imaging visits whenever possible to minimize the number of times patients traveled to the hospital. Similarly, we collaborated with our surgical oncology colleagues to ensure patients who might benefit from a surgical consultation, including those with highly suspicious findings for malignancy, were evaluated by a breast surgeon on the same day as the imaging visit. Our fellows were central in implementing these processes and coordinating patient care. Finally, fellows gained experience through taking part in broader risk mitigation processes, including universal use of personal protective equipment and performance of mandatory daily COVID-19 symptom attestations for on-site work.

INTERPERSONAL AND COMMUNICATION SKILLS

Physical distancing and risk mitigation measures resulted in a sudden change in attending-trainee communication including substantially less in-person interactions with patients and colleagues. At the same time, rapidly evolving conditions at our institution and within our community placed a high premium on clear, consistent, and effective communication. These factors created a rich environment for our fellows to grow in this domain, not only through their role as communicators and care coordinators but also by witnessing communication processes throughout the institution.

From the outset of the pandemic era, it was clear that the implementation of risk mitigation processes and the continuation of clinical, educational, and research work depended on the successful adoption of videoconferencing and other remote work tools by all division members including physicians,

technologists, staff assistants, and administrators. A physician lead was designated to evaluate and gain domain expertise on remote work solutions, integrate these into the daily functioning of the division, create brief illustrated step-by-step user guides, and provide individual support as needed to all physician and nonphysician members of the division, which allowed for rapid adaptation to new clinical workflows.

To coordinate the development and implementation of division-wide risk mitigation systems and processes, all relevant documents were placed into one central folder on an institutional server accessible by all divisional personnel regardless of physical location through a virtual private network. This was intended to establish consistent processes during a time of rapid changes by ensuring staff could access a uniform updated set of policies at all times. Similarly, at the departmental and institutional level, information was also made available through centralized electronic repositories.

Prior to the pandemic, all fellows participated in daily team huddles held in the diagnostic imaging clinic at 8:00 AM, which were attended in-person by all in-house personnel that day including assistants, technologists, and practice managers. During this huddle, the team reviewed assigned clinical roles, diagnostic imaging and procedure schedules, and updates which may impact clinical workflow. To support physical distancing during the pandemic, this in-person daily huddle adopted a virtual format with a group videoconference at 8:00 AM. These huddles assumed even greater importance, as they provided an opportunity to review and reinforce risk mitigation processes within the division and at the departmental and institutional level. Off-site fellows and attendings joined virtually, to stay informed of daily clinical volumes, case types amid the pandemic, and important updates pertaining to divisional changes.

Over this period, fellows learned to prioritize, facilitate, and coordinate patient care via clear and effective telecommunication with their peers, attending radiologists, and technologists. With all parties using facemasks, fellows continued to hone their verbal communication skills by conveying results and recommendations to patients in an empathetic and comprehensible manner. Role modeling of effective telecommunication by attending radiologists, as well as clear and frequent constructive feedback to trainees, also aided in enhancing trainees' interpersonal and communication skills.

PATIENT CARE

Growth along this competency was heavily impacted by decreased volumes. As a result, only one to two fellows worked on-site every day amid the peak period of the pandemic. Although off-site fellows could not directly participate in patient care, technological solutions were used to maximize their exposure to clinical cases and create a "remote" clinical learning environment. Through use of our institutional virtual private network and application virtualization tools, off-site fellows could access our picture archiving and communication system (PACS), mammography information

system, and electronic health record to review clinical cases encountered each day.

Fellows also had the opportunity to receive 4K ultra-high definition monitors from our department to supplement home workstations. Monitors were used to review mammogram, ultrasound, and MRI images for educational purposes. These monitors also allow off-site fellows to observe and participate in multidisciplinary conferences. Interpretation from home workstations for clinical purposes was not performed since this would require workstations to meet mammography practice parameters, including testing by a medical physicist prior to clinical use (7).

To support continued training in screening mammography for our fellows, worklists on our PACS were created containing screening mammograms previously finalized over 1 year ago for fellows to interpret using clinical workstations when on-site. Fellows were able to interpret studies blinded to final outcomes, simulating the experience of a real-world clinical setting and helping to augment the clinical volume. Fellows were responsible for comparing their own personal assessment with the true clinical outcome, with on-site attending staff readily available to answer questions and discuss specific cases. This learning opportunity was also provided to residents, who could read screening exams from remote work stations.

To maximize exposure to clinical cases for off-site fellows, the division continued daily 4:00 PM videoconferences, which were attended by all attendings and fellows. The on-site fellow led the conference under the supervision of the on-site attending. Teaching points encountered over the course of the clinical day were presented. Radiology-pathology concordance was then discussed for biopsy results completed each day. During these conferences, fellows reviewed clinical history, diagnostic work-up, biopsy images using PACS, and pathology results. Radiology-pathology concordance was established through staff consensus. Discussions focused on the rationale behind steps in management of complex cases, biopsy approaches (modality and techniques), and alternative options for technically challenging cases. Time was allotted for fellows to ask questions about the diagnostic pathway and clinical management decision steps for each case.

As previously mentioned, we minimized the number of personnel present in the room during procedures. The attending radiologist generally assumed operation of the ultrasound machine, while directly supervising the fellow during ultrasound procedures. This new workflow helped

promote greater confidence and independent in decision-making, and aided in strengthening procedural competence.

MEDICAL KNOWLEDGE

Continued advancement of our fellows within this core competency was supported by a redesigned virtual didactic conference schedule (Table 3). Prior to embarking on this new academic calendar, technological support was provided to all attendings and fellows to ensure the successful use of video-conference tools for these virtual conferences.

Previously scheduled weekly, hour-long faculty-led educational conferences on Thursday afternoons continued. Guest lecturers were invited from related specialties including genetics, breast surgery, and medical oncology to provide additional learning opportunities. Fellows also presented on breast cancer-related topics and led journal clubs to support peer-to-peer teaching and to promote self-learning while working remotely. In addition, the daily afternoon radiology-pathology conference provided off-site fellows with continued exposure to clinically encountered cases, while also serving as informal didactic sessions. Finally, all fellows could attend virtual multidisciplinary breast oncology clinics (which review patients with new cancer diagnoses) and breast oncology tumor board (which reviews patients with known cancer facing complex management questions), attended by breast surgery, breast oncology, radiation oncology, pathology, and breast imaging services. Prior to the pandemic, only the fellow assigned to tumor board would be present to derive learning points from these sessions. Switching to a videoconference format provided accessibility for all fellows including those working off-site. Finally, breast imaging, faculty-led virtual resident educational lectures were also accessible via videoconferencing for our fellows.

Remote-work solutions allowed fellows to continue their work on quality improvement and research projects. During the peak months, fellows were provided the opportunity to prepare manuscripts for their accepted abstracts to annual conferences that had been canceled due to the pandemic. A centralized fellows' educational folder and reference library was created for educational presentations, in addition to journal club and research articles.

As part of the residency-wide virtual education curriculum for off-site residents, attending physicians within the breast imaging division held live videoconference-based hour-long

TABLE 3. Redesigned Educational Conference Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
Breast oncology tumor board					7:30 AM
Virtual breast imaging huddle	8:00 AM	8:00 AM	8:00 AM	8:00 AM	8:00 AM
Multidisciplinary tumor clinic	1:30 PM	1:30 PM	1:30 PM	1:30 PM	
Resident lecture			3:00 PM		
Radiology-pathology conference	4:00 PM	4:00 PM	4:00 PM	4:00 PM	4:00 PM
Fellows teaching conference				4:15 PM	

lectures on a weekly basis. A web-based mammography learning program developed by faculty within our division, was made available for residents to support remote learning. The program consisted of 35 case-based learning modules. Each case module began with standard screening mammography images that trainees could interpret, answer case-based questions, and determine next steps in management. Answers were provided to trainees immediately following completion of each module. Scores were automatically stored and sent to educational leadership, which could be used to guide targeted feedback

PRACTICE-BASED LEARNING AND IMPROVEMENT

Fellows continued to progress within this domain through continued participation in clinical work. In particular, temporary suspension of nonessential elective procedures during the pandemic necessitated alternative management approaches to breast cancer treatment. Through their continued participation in daily multidisciplinary oncology conferences via videoconferencing, our fellows participated in complex decision-making processes involved in delivering appropriate cancer care during this period. Furthermore, the process of adapting to rapid changes in clinical workflow and maintaining high-quality care delivery amid ongoing uncertainty, created new opportunities for self-reflection and insight into one's strengths and limitations.

PROFESSIONALISM

At its highest level, professionalism means identifying and addressing barriers to ethical care, taking ownership of health-care system outcomes, and meeting high professional expectations. At our institution, as in others across the country and around the world, models of professional behavior in response to the COVID-19 pandemic have been abundant. The fellows' consistent participation in weekly divisional planning meetings, as well as department/institution-wide town hall forums, allowed them to contribute to implementation of safe, high quality, and equitable care during a period of system-wide stress and uncertainty.

The hospital and department provided resources to support emotional and physical health, with webinars and informational resources addressing topics ranging from managing parental challenges, particularly with regard to childhood education, to exercising in the era of COVID-19. Virtual group yoga, strength training, and home cooking session were also provided. These webinars and informational resources were made available for access at any time on hospital and departmental wellness websites, and the availability of these resources were widely broadcasted through daily and weekly e-mails. In addition, resources to support mental

health during this period were widely distributed to all trainees. Educational leadership within the division also scheduled regular check-in meetings and were readily available for discussions with the fellows, both collectively and individually, to help manage trainee anxiety and concerns.

LESSONS LEARNED

As we reflect on the changes that occurred within our academic breast imaging program during the height of the pandemic, it became apparent that new opportunities have arisen to support the continued growth of our trainees largely through maximizing the use of remote work and communications tools. The shift of multidisciplinary oncology conferences to a virtual format has expanded access of these rich learning opportunities to all fellows. In addition, the creation of fellow-led, peer-to-peer educational conferences have provided the chance for fellows to improve their teaching skills and allowed the division to include trainees both on- and off-service. Through our phased reopening, these processes will be continued with incoming fellowship and resident classes, who have returned to on-site clinical rotations. Simulated screening mammography worklists are still being used to support clinical education for all trainees. Continued risk mitigation practices including paperless clinical workflow and same day care have helped our division to optimize our care delivery process, demonstrating to trainees innovative methods on how to improve patient care and workflow efficiency. Finally, videoconferencing capabilities have also helped to support social and wellness activities, in addition to educational, clinical, and research activities. Many of these changes will continue indefinitely, which will benefit trainees for years to come.

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