Advances in Radiation Oncology

Our Experience Leading a Large Medical Physics Practice During the COVID-19 Pandemic

--Manuscript Draft--

Manuscript Number:	ADVANCESRADONC-D-21-00026
Article Type:	Critical Review
Section/Category:	Physics Contribution
Corresponding Author:	Julianne Pollard-Larkin Houston, TX UNITED STATES
First Author:	Julianne Pollard-Larkin
Order of Authors:	Julianne Pollard-Larkin
	Tina M. Briere, PhD
	Rajat J. Kudchadker, PhD
	Ramaswamy Sadagopan, MS
	Paige L. Nitsch, MS
	Xin A. Wang, PhD
	Mohammad Salehpour, PhD
	Jihong Wang, PhD
	Sastry Vedam, PhD
	Christopher L. Nelson, PhD
	Narayan Sahoo, PhD
	Xiaorong R. Zhu, PhD
	Laurence E. Court, PhD
	Peter A. Balter, PhD
	Ivy J. Robinson
	Jinzhong Yang, PhD
	Rebecca M. Howell, PhD
	David S. Followill, PhD
	Stephen Kry, PhD
	Sam A. Beddar, PhD
	Mary K. Martel, PhD
Abstract:	COVID-19 has presented Radiation Oncology with unique challenges. This article presents suggestions from our large Radiation Oncology practice on how to provide Physics coverage during the COVID-19 pandemic. Our facility encompasses 4 smaller Houston Area Locations (HALs), a main campus with 8 distinct services based on treatment site (ie. Thoracic, Head and Neck, Breast, Gastrointestinal, Gynecology, Genitourinary, Hematologic Malignancies, Melanoma and Sarcoma and Central Nervous System/Pediatrics), a Proton Center facility, an MR-Linac, a Gamma Knife clinic and an array of brachytherapy services. Due to the scope of our services, we have gained experience in dealing with the rapidly changing pandemic effects on our clinical practice. The goal of this paper is to provide a resource to other Medical Physics practices in search of workflows that have been resilient during these challenging times.

Our Experience Leading a Large Medical Physics Practice During the COVID-19 Pandemic

Short title: **Medical Physics Practice During COVID-19**

Julianne M. Pollard-Larkin, PhD[1], Tina M. Briere[1], PhD, Rajat J. Kudchadker[1], PhD, Ramaswamy Sadagopan[1], MS, Paige L. Nitsch[1], MS, Xin A. Wang[1], PhD, Mohammad Salehpour[1], PhD, Jihong Wang[1], PhD, Sastry Vedam[1], PhD, Christopher L. Nelson[1], PhD, Narayan Sahoo[1], PhD, Xiaorong R. Zhu[1], PhD, Laurence E. Court[1], PhD, Peter A. Balter[1], PhD, Ivy J. Robinson[2], AAS, Jinzhong Yang[1], PhD, Rebecca M. Howell[1], PhD, David S. Followill[1], PhD, Stephen Kry[1], PhD, Sam A. Beddar[1], PhD, and Mary K. Martel[1], PhD

1. *Department of Radiation Physics, MD Anderson Cancer Center, Houston, Texas 77030, USA 2. Department of Radiation Oncology, MD Anderson Cancer Center, Houston, Texas 77030,USA*

* Corresponding author: Julianne Pollard-Larkin, 1400 Pressler Street, Unit 1420, Houston, TX 77030, jmpollard@mdanderson.org

No conflicts of interest.

Funding: None

Abstract

COVID-19 has presented Radiation Oncology with unique challenges. This article presents suggestions from our large Radiation Oncology practice on how to provide Physics coverage during the COVID-19 pandemic. Our facility encompasses 4 smaller Houston Area Locations (HALs), a main campus with 8 distinct services based on treatment site (ie. Thoracic, Head and Neck, Breast, Gastrointestinal, Gynecology, Genitourinary, Hematologic Malignancies, Melanoma and Sarcoma and Central Nervous System/Pediatrics), a Proton Center facility, an MR-Linac, a Gamma Knife clinic and an array of brachytherapy services. Due to the scope of our services, we have gained experience in dealing with the rapidly changing pandemic effects on our clinical practice. The goal of this paper is to provide a resource to other Medical Physics practices in search of workflows that have been resilient during these challenging times.

The US has just surpassed 360,000 COVID-19 deaths at the onset of the distribution of the first FDA-approved COVID-19 vaccine (Pfizer BioNTech and Moderna, ModernaTX, Inc) over the course of the last 10 months of this pandemic[1,2]. Never before has the radiotherapy community been more aware of the double-edged sword of our practice, we must contend with not only treating cancer but protecting ourselves from possible exposure to COVID-19 while doing so. The goal of this article is to discuss strategies for medical physicists to help minimize this risk for radiation oncology patients and staff to the as low as reasonably achievable level during this crisis. The COVID-19 pandemic is a quickly changing situation, therefore, our suggestions are neither complete nor perfect, and each medical physics practice should follow federal, state, local, and institutional guidance first and foremost. This is not meant to be a guideline or task group report. Importantly, we also discuss how to strategically plan for an

increase in patient treatment volume as the quarantine efforts are scaled back after each peak of COVID-19 cases has subsided.

Our Department of Radiation Oncology is divided based on treatment site, specialty, and location. We have eight different specialties based on treatment site (e.g., breast, genitourinary), the Proton Therapy Center (PTC), four centers in the Houston area outside of our main campus, and unique radiation oncology programs such as the Imaging and Radiation Oncology Core (IROC) that operate both on and off the main campus. On our main campus, we have 17 linear accelerators (linacs), 2 Gamma Knife units, and an Elekta MR-Linac. In addition, our main campus offers an array of brachytherapy, including high-dose-rate (HDR) intraoperative radiotherapy, pulsed-dose-rate brachytherapy, prostate seed implants, and HDR for gynecological disease. For every linac, routine quality assurance (QA) is overseen by at least two qualified medical physicists (QMPs), and all specialties and services are staffed by a specific team of credentialed QMPs. Altogether, we have a staff of 68 QMPs in our department who cover the clinical workload as well as our research objectives. Beyond our physics staff, we have a core group of nearly 110 certified radiation therapists (RTTs), 100 certified clinical medical dosimetrists assigned to specific body sites or specializations, nearly 60 radiation oncologists, 20 radiation oncology medical residents, 7 medical physics residents, 10 physics assistants, 5 in-house linac engineers, and 10 machine shop technicians.

Our department's scope and size make us an ideal testing ground for best practices in radiation oncology. Notably, when the World Health Organization declared the global pandemic on March 11, 2020, our institution had already implemented an infection screening program, restricted access and entry into our campus and begun banning patients from infection hotspot locations. Later, our institution implemented a mask requirement for all staff, patients, and

visitors by early April and requested a 2-week quarantine for anyone coming from out of state onto our campus. Finally, we implemented having all patient-facing staff wear face shields in the clinic in addition to face masks. Our division developed a COVID-19 strategy in alignment with institutional goals. The key components of this strategy involved reducing the number of patients receiving treatment within the Department of Radiation Oncology, practicing social distancing, participating in institutional screening efforts, wearing personal protective equipment (PPE), and creating a tracer team.

As QMPs with core responsibilities including machine QA of devices used in radiotherapy and physical presence at special procedures such as stereotactic body radiotherapy (SBRT), Gamma Knife radiosurgery, and MR-Linac–based treatments, we need provisions to lower our potential for exposure to COVID-19. Our work cannot be completely done remotely, and we must prudently develop workflows that allow us to maintain high-quality work with a risk of infection as low as reasonably achievable.

This concept of "as low as reasonably achievable" (ALARA) and risk mitigation is not new for QMPs. However, we are now focused on viral spread in addition to stray radiation. Our familiar terminology for radiation protection, including time, distance, and shielding, still applies to the COVID-19 pandemic. To limit the spread of COVID-19 within a treatment center, the time of exposure to potentially contaminated surfaces and people should be minimized, staff and patients should maintain at least 6 feet of distance from others, and everyone should wear the proper PPE to shield against pathogens. Asymptomatic individuals are estimated to make up 17.5-33% of the COVID-19–positive population, and as of April 9, 2020, more than 9000 health care workers had tested positive for COVID-19.[3,4]

Over the course of this pandemic, physicists should wear the required PPE in alignment with Centers for Disease Control and Prevention guidelines and as provided by their medical centers. Unfortunately, it is possible for a lab coat to carry bacteria and viruses.[5] Therefore, many physicists at our center now voluntarily wear scrubs, which are removed at the end of each shift to help protect their families and others. While wearing PPE, we have found it necessary to speak clearer and louder than normal, as masks and shields can muffle and distort speech. Therefore, when necessary, we reinforce our statements with commonly understood hand signals (e.g., thumbs up or down), speak loudly, and use proper diction to prevent being misunderstood.

The Role of Imaging in Radiation Oncology During the COVID-19 Pandemic

Experience in China, Japan, Korea, Italy, and other European countries has demonstrated the great value of thoracic imaging in the diagnosis of and screening for COVID-19 infection, monitoring of therapeutic efficacy, and assessment of patient discharge.[6,7] For this screening purpose, a high-resolution computed tomography (CT) scan is highly preferable, but portable chest X-rays can also be helpful for patients who are immobile (bedside imaging).

Several centers have reported accidentally identifying COVID-19–positive cancer patients under treatment or at simulation in radiation oncology via CT or cone beam CT (CBCT).[8,9] Our campus had such a finding for one of our thoracic SBRT patients, and the report was recently published (Figure 1). [10] Imaging provides an opportunity to identify infected patients who are missed through common screening checks implemented by centers. At simulation and throughout the patient's treatment, our physicians and physicists are now asked to more closely inspect patients' CT and CBCT data sets for any signs of bilateral ground glass lesions that are

indicative of COVID-19 and to flag anything suspicious. Notably, due to the quality of CBCTs and motion artifacts, we have not had another incidental finding of COVID-19 infection.

Several institutions are developing automated software tools to help identify COVID-19–suspicious lung opacities on CT or CBCT scans, none of which are recommended for upfront screening of patients. Researchers in the Wuhan province of China showed the efficacy of using a deep-learning neural network for COVID-19 detection to differentiate CT scans of COVID-19–positive patients from those of patients with community-acquired pneumonia or without pneumonia.[11] The reported per-exam sensitivity and specificity rates detecting COVID-19 positive patients were 90% and 96%, respectively.[11] Some automated tools also help predict when an infected patient may need additional ventilation.[12] QMPs should educate themselves about the tools available to aid their centers in screening patient images for signs of COVID-19 infection and then work with their physicians to decide how to implement additional screening of patients. In addition, evidence is growing to show that a growing number of recovered COVID-19 patients are suffering from myocardial injury and this heart damage can be best visualized with the help of cardiac magnetic resonance imaging (CMR).[13]

MR-Linac Operation During the COVID-19 Pandemic

Our MR-Linac program using an Elekta 1.5T MR-Linac was formally commissioned in December 2018. The MR-Linac involves online plan adaptation, requiring the presence of clinical personnel from different disciplines in addition to RTTs at the treatment console, including dosimetrists, physicists, and physicians.

In preparation for handling clinical operations during the anticipated spread of COVID-19 among our local population, a temporary staffing model was developed for personnel required to be present at the MR-Linac console with one RTT and one physicist. The attending physician

was allowed to remotely review the daily image registration and approve the adaptive plan through videoconferencing. Preference for treatment with the MR-Linac was also given to hypo-fractionated cases compared to conventional fractionation cases.

Stereotactic (SBRT) and Total Skin and Body Treatments During the COVID-19 Pandemic

In the thoracic physics group, physicists actively participated in all SBRTs for all fractions before the COVID-19 crisis and continued to do so during it. In addition, a physicist is present during all four-dimensional CT simulations, and this is mandatory for all SBRTs. Physicists must also be available for all troubleshooting in the clinic whether any patient alignment issues are discovered by therapists during imaging alignment or if a machine issue occurs. And radiation oncologists review the daily CBCT-based alignment at the treatment console.

In our head and neck, lymphoma, myeloma, melanoma, and sarcoma services, physicists maintain their typical coverage of SBRT cases and have reduced their coverage to just one physicist in person for all SBRT cases. We did not change any of our staffing or procedures for total-body irradiation. For our total skin electron treatments, we traditionally performed thermoluminescent dosimeter (TLD) measurements for each patient but stopped this due to potential infection concerns.

Gamma Knife Radiosurgery During the COVID-19 Pandemic

The Leksell Gamma Knife Icon (Elekta AB, Stockholm, Sweden) offers two options for stereotactic treatment of the brain: framed and frameless mask-based. At our institution, a large team is assembled for framed treatments. Specifically, a neurosurgeon, neurosurgery advanced practice nurse, and dedicated Gamma Knife nurse frame the patient on the morning of treatment.

Frameless mask-based treatment, on the other hand, is an outpatient procedure that requires a smaller treatment team. The neurosurgeon can consult with the patient and review the treatment plan remotely. Following treatment, the patient can immediately leave the hospital without observation. Thus, no Gamma Knife nurses, medical assistants, or postoperative recovery unit nurses are required for this procedure. Our institution has been giving mask-based treatment to patients with the Leksell Gamma Knife Icon for more than a year. Before the COVID-19 pandemic, the majority of lesions treated with the frameless option were large ones that required multiple treatment fractions. Since the pandemic started, frameless treatment has become more attractive for smaller lesions treated in single fractions because of the reduced staffing and hospital resources required for it.

Brachytherapy During the COVID-19 Pandemic

At our institution, we perform HDR (high dose rate), pulsed-dose-rate, and low-dose-rate brachytherapy. Because these are mostly invasive procedures performed in the operating room, they have been affected by the pandemic in several aspects.

Because most institutions have only a few individuals who specialize in HDR and are authorized and credentialed to perform brachytherapy, working out a skeleton crew schedule for HDR is more challenging than for traditional external beam radiotherapy procedures. Currently, our physicists and dosimetrists who participate in brachytherapy procedures are undergoing fit testing for N95 masks. Because several physicians, physicists, and dosimetrists may work off-site, we had to quickly implement contouring, treatment planning, and plan review by the off-site staff using Webex videoconferencing software (Cisco Systems, San Jose, CA). Webex has also been useful for chart rounds peer review and case discussion. Finally, post-procedure equipment

disinfection and sterilization have also become cumbersome due to fewer trained sterile processing staff working on-site.

For all of our brachytherapy practice, source exchange has become challenging because the vendor engineers are few in number and routinely travel to adjacent states to replace sources and fix equipment that have undergone COVID-19 based travel restrictions. Issues such as these must be identified in advance and brought to the attention of administrators immediately so that optimal solutions can be worked out. Regarding mandatory annual emergency HDR training, the licensing and inspection managers in Texas have agreed to our proposal of creating a video recording of an emergency HDR drill and requiring individuals who must undergo annual refresher training to watch the recording and then hold in-person training when the pandemic subsides and we can more freely interact. For our HDR-based intraoperative radiotherapy procedures, we did have to temporarily have our gastrointestinal physics group verify completion and documentation of physician peer review prior to treatment delivery due to a mandate issued by our governor to limit certain surgical procedures.

Proton Therapy During the COVID-19 Pandemic

Our Proton therapy center (PTC) is an outpatient treatment facility. Before the pandemic, treatment hours were 4:00 AM to 12:00 AM. The treatment hours were reduced to 6:00 AM to 10:00 PM after risk-reduction strategies were implemented to prepare for any possible therapy staff shortages due to the infection. The physics tasks associated with the patient treatment and machine QA activities were continued at the same level as before implementation of the COVID-19 precautions. All of the dosimetrists were required to work from home, and only two physicists were required to be on-site during the patient treatment hours: one for the morning shift and the

other for the evening shift. Off-site physicists were required to work from home but were allowed to enter the PTC when the need arose.

Houston-Area Location Operation During the COVID-19 Pandemic

Our Houston Area location (HALs) satellite center structure consists of 4 centers with 12 linacs and 5 HDR units. Each center is typically staffed with two or three physicists. During the pandemic, on-site staffing has been limited to one physicist per site. All patient-specific pretreatment QA at the centers is being performed by one physicist at one site after typical clinical hours to minimize their presence at the treatment machine. Two physicists are on-site only on the days when cervical brachytherapy is delivered. The remaining staff work remotely from home doing the bulk of the computer work while the on-site physicists complete hands-on clinical tasks. Physicists now rotate 1 week working on-site and 1 week working remotely.

IROC Houston QA Center Operation During the COVID-19 Pandemic

IROC Houston is located several kilometers from the main campus of X. We implemented a plan to continue to provide core support and quality audits to institutions participating in the National Cancer Institute's National Clinical Trial Network clinical trials that allows for most staff to work remotely. The plan requires us to have a skeleton crew in the office (typically five or six individuals). We are now requiring 80% of our staff to work off-site. Their responsibility is to ship and receive remote audit materials such as optically stimulated luminescent dosimeter/TLD output check phantoms and our end-to-end QA phantoms and to perform readout of irradiated dosimeters, tasks that cannot be performed remotely. All other activities, including analysis of results and reporting them back to the institutions, are conducted remotely. Remote use of the IROC database

has facilitated the notification of required checks of dosimeter analysis as well as analysis and reporting of results in a manner almost equal to that of all individuals are on-site. Ongoing information technology development continues to improve the workflow and ease the communication and processes for these newly remote activities. The one audit that had to be discontinued was the on-site dosimetry review visit. These visits were stopped due to travel limitations from X and the visitor restrictions in place at other institutions to be visited. Except for the on-site dosimetry review visits, we are meeting the needs of the nearly 2000 institutions participating in our quality audit peer review program.

Radiation Dosimetry Service Operation During the COVID-19 Pandemic

The X Radiation Dosimetry Service (RDS) is located 4 km from the main campus and is not in a clinical area. Independent peer review services make up an essential component of patient safety at radiotherapy centers throughout the world. Thus, we are maintaining our radiation dosimetry operations, but taking specific precautions to minimize the risk of COVID-19 infection among our staff. To accomplish this, we implemented a mixed model of working at home and staggered on-site shifts to reduce our staff to 25% on-site at any given time. Much of our work requires physical presence, such as reading, shipping, and receiving TLDs and irradiation of standards and controls. For RDS staff whose work requires being present on-site, we established morning and afternoon shifts with a 30-minute gap in between to ensure no overlap. Other staff are working from home 60% or 100% of the time.

We have implemented several other safety measures for our staff, including 1) limiting building access to approved essential workers, 2) limiting building access to a single point of entry, 3) COVID-19 screening at entry that includes measuring temperature and answering screening

questions, 4) regular disinfection of high-touch surfaces, and 5) mandatory wearing of face masks. We also require social distancing at all times.

Accredited Dosimetry Calibration Laboratory Operation During the COVID-19 Pandemic

The X Accredited Dosimetry Calibration Laboratory (ADCL) has faced serious obstacles during the COVID-19 pandemic. Its operations are essential to providing calibrations for radiotherapy facilities around the world. However, our facility is located in the middle of the radiotherapy clinic, and because ADCL staff do not directly perform patient care for our institution, our presence at the ADCL conflicted with the institution's priority to minimize the number of people present in clinical space. For a period during the height of the COVID-19 pandemic, the lab was even forced to suspend calibration activities.

Clinical Research During the Pandemic

At the onset of the pandemic, all basic science and clinical research personnel (research nurses, clinical data coordinators, research data coordinators, and regulatory staff) at X were instructed to work from home. To that effect, all clinical trials that could not use remote methods of interaction were suspended. Therefore, new patient enrollment for all protocols requiring any specimen collection, face-to-face interaction, etc., was halted for a period of several months until the institution decided to resume these trials. In March 2020, of the 370 open protocols within the Division of Radiation Oncology, only 41 were allowed to remain open for new patient enrollment. At the height of the pandemic, all activities related to patient enrollment were performed remotely using institutionally-approved media devices and applications. The institution's scientific review committees and internal review boards kept operating normally, reviewing and approving new protocols as usual but worked remotely through Webex.

Education of residents and trainees

Our trainees are still engaged with their computer-based research projects while access to lab spaces on campus are reduced. Based on our experience working remotely, the single most important factor in maintaining a research group is a strong, continuous focus on morale, both for the individuals and the group. Our research faculty take a multifaceted approach to accomplishing this, including daily virtual huddles, daily formal group meetings and an increase in science journal club virtual discussions.

Physics Leadership During a Crisis

Leadership, effective communication, transparency, reliability, emotional awareness, and empathy are critical during times of instability. Luckily, QMPs are leaders by default. We are the resources physicians, RTTs, and dosimetrists seek to understand the complex Radiation Oncology processes and their ramifications in radiation oncology. We must communicate effectively with all of the teams we support and strategically coordinate every aspect of how to facilitate radiotherapy treatment during the COVID-19 crisis. Daily conversations with Department of Radiation Oncology leadership via phone or a remote video software tool are necessary, and the decisions made during these discussions should be relayed to all physics staff as needed.

Beyond ensuring that departmental policies are in alignment with institutional policies regarding COVID-19, physicist leaders should ensure that their department keeps up to date with national Radiation Oncology guidelines and recommendations as they are made available by the American Association of Physicists in Medicine and American Society for Radiation Oncology. The American Association of Physicists in Medicine created a new list of suggestions for how to safely practice medical physics during the COVID-19 pandemic, as did the International Atomic

Energy Agency.[14,15] We should set manageable departmental goals that are feasible given departmental resources. With proper assessment of our quality and safety error reporting data and maintaining an accounting of our staff's well-being, we can improve our chances of delivering effective treatment to our Radiation Oncology patients.

Table

Table 1 Suggestions for safe medical physics practice during the COVID-19 pandemic

1. Rotate staff to minimize spread of COVID-19 (e.g. 1 week on, 1 week off)
2. Train back-up QMPs for special procedures
3. Document workflows, policies, and procedures
4. Practice timely, daily effective communication
5. Identify new tools to help with imaging-based screening
6. Maintain awareness of up-to-date official data/reports
7. Wear proper PPE
8. Disinfect equipment before and after use
9. Wash hands for the recommended time after each patient/QA interaction
10. Monitor quality and safety trends
11. Adapt practice to the changing pandemic up to or through the endemic stage

Figure 1 CT- on- rails image of an asymptomatic **{"cancer"?}** patient prior to COVID-19 infection diagnosis.