Critical Review

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

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Abstract

Purpose: To provide a series of suggestions for other Medical Physics practices to follow in order to provide effective radiation therapy treatments during the COVID-19 pandemic.

Methods and Materials: We reviewed our entire Radiation Oncology infrastructure to identify a series of workflows and policy changes that we implemented during the pandemic that yielded more effective practices during this time.

Results: We identified a structured list of several suggestions that can help other Medical Physics practices overcome the challenges involved in delivering high quality radiotherapy services during this pandemic.

Conclusions: 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. Our paper provides a resource to other Medical Physics practices in search of workflows that have been resilient during these challenging times.

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Introduction

The United States has just surpassed 360,000 COVID-19 deaths at the onset of the distribution of the first COVID-19 vaccines approved by the US Food and Drug Administration (Pfizer BioNTech and Moderna, ModernaTX, Inc) over the course of the last 10 months of this...
Never before has the radiation therapy community been more aware of the double-edged sword of our practice because we must contend with not only treating patients with cancer but also protect 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 an 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 review 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 8 different specialties based on treatment site (eg, breast, gynecological): the proton therapy center (PTC), 4 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 magnetic resonance (MR) linac. In addition, our main campus offers an array of brachytherapy, including high-dose-rate (HDR) intraoperative radiation therapy, pulsed-dose-rate brachytherapy, prostate seed implants, and HDR for gynecologic disease. For every linac, routine quality assurance (QA) is overseen by at least 2 qualified medical physicists (QMPs), and all specialties and services are staffed by a team of credentialed QMPs. All together, 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 at 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 radiation therapy and physical presence at special procedures (eg, stereotactic body radiation therapy [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 (ALARA).

This concept of 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% to 33% of the COVID-19-positive population, and as of April 9, 2020, >9000 health care workers had tested positive for COVID-19.

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, a laboratory coat can carry bacteria and viruses. 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 that speaking clearer and louder than normal is necessary because masks and shields can muffle and distort speech. Therefore, when necessary, we reinforce our statements with commonly understood hand signals (eg, thumbs up or down), speak loudly, and use proper diction to prevent being misunderstood.

Role of imaging in radiation oncology during COVID-19 pandemic

Experience in China, Japan, Korea, as well as 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. For this screening purpose, a high-resolution computed
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 patients with cancer under treatment or at simulation in radiation oncology via CT or cone beam CT.\(^8,9\) Our campus had such a finding for one of our thoracic SBRT patients, and the report was recently published (Fig 1).\(^10\) Imaging provides an opportunity to identify infected patients who are missed through common screening checks implemented by centers. At simulation and throughout patient treatment, our physicians and physicists are now asked to more closely inspect patients’ CT and cone beam CT data sets for any signs of bilateral ground glass lesions that are indicative of COVID-19 infection, and flag anything suspicious. Notably, due to the quality of cone beam CT scans 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 cone beam CT 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-examination sensitivity and specificity rates detecting patients positive for COVID-19 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 shows that a growing number of patients who recovered from COVID-19 are suffering from myocardial injury, and this heart damage can be best visualized with the help of cardiac MR imaging.\(^13\)

**Magnetic resonance linac operation during 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 of 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 1 RTT and 1 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 hypofractionated cases compared with conventional fractionation cases.

**Stereotactic and total skin and body treatments during 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. In addition, a physicist is present during all 4-dimensional CT simulations, which is mandatory for all SBRTs. Physicists must also be available for all troubleshooting at the clinic in case patient alignment issues are discovered by therapists during imaging alignment or if a machine issue occurs. Radiation oncologists review the daily cone beam CT-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 1 physicist in person for all SBRT cases. We did not change any 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 due to potential infection concerns.

**Gamma Knife radiosurgery during COVID-19 pandemic**

The Leksell Gamma Knife Icon (Elekta AB, Stockholm, Sweden) offers 2 options for stereotactic treatment of the brain: Framed and frameless mask-based treatment. 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. On the other hand, frameless mask-based treatment is an outpatient procedure that requires a smaller treatment team. The neurosurgeon can consult with the patient and review the treatment plan remotely. After 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 treatments to patients with the Leksell Gamma Knife Icon for >1 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.

**Brachytherapy during COVID-19 pandemic**

At our institution, we perform HDR, 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. Most institutions have only a few individuals who specialize in HDR and are authorized and credentialed to perform brachytherapy; thus, working out a skeleton crew schedule for HDR is more challenging than for traditional external beam radiation therapy 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 offsite, we had to quickly implement contouring and treatment planning and plan review by offsite staff using WebEx videoconferencing software (Cisco Systems, San Jose, CA). WebEx has also been useful for chart rounds, peer review, and case discussion. Finally, postprocedure equipment disinfection and sterilization have also become cumbersome due to fewer trained sterile processing staff working onsite.

For our entire brachytherapy practice, source exchange has become challenging because 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, 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 to more freely interact. For our HDR-based intraoperative radiation therapy procedures, we had to temporarily have our gastrointestinal physics group verify completion and documentation of physician peer review before treatment delivery due to a mandate issued by our governor to limit certain surgical procedures.

**Proton therapy during COVID-19 pandemic**

Our PTC is an outpatient treatment facility. Before the pandemic, treatment hours were 4:00 AM to 12:00 AM. Treatment hours were reduced to 6:00 AM to 10:00 PM after risk-reduction strategies were implemented to prepare for possible therapy staff shortages due to the infection. Physics tasks associated with patient treatment and machine QA activities were continued at the same level as before the implementation of the COVID-19 precautions. All dosimetrists were required to work from home, and only 2 physicists were required to be onsite during patient treatment hours (1 for morning shift, the other for evening shift). Offsite physicists were required to work from home, but were allowed to enter the PTC when needed.

**Houston-area location operation during COVID-19 pandemic**

Our Houston-area location satellite center structure consists of 4 centers with 12 linacs and 5 HDR units. Each center is typically staffed with 2 or 3 physicists. During the pandemic, onsite staffing has been limited to 1 physicist per site. All patient-specific pretreatment QA at the centers is performed by 1 physicist at 1 site after typical clinical hours to minimize their presence at the treatment machine. Two physicists are onsite only on days when cervical brachytherapy is delivered. The remaining staff work remotely from home doing the bulk of computer work while onsite physicists complete hands-on clinical tasks. Physicists now rotate working 1 week onsite and 1 week remotely.

**Imaging and radiation oncology core Houston QA center operation during COVID-19 pandemic**

IROC Houston is located several kilometers from the main campus of The University of Texas MD Anderson Cancer Center. 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 at the office (typically 5 or 6 individuals). We now require 80% of our staff to work offsite. 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, as well as perform readout of irradiated dosimeters (ie, tasks that cannot be performed remotely). All other activities, including analysis of results and reporting back to institutions, are conducted remotely. The remote use of the IROC database has facilitated the notification of required checks of the dosimeter analysis, as well as analysis and reporting of results in a manner that is almost equal to that of all individuals onsite. 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 onsite dosimetry review visit. These visits were stopped due to travel limitations from MD Anderson and the visitor restrictions in place at other institutions to be visited. Except for the onsite 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 COVID-19 pandemic

The MD Anderson radiation dosimetry service is located 4 km from the main campus and not in a clinical area. Independent peer review services make up an essential component of patient safety at radiation therapy 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 onsite shifts to reduce our staff to 25% onsite at any given time. Much of our work requires physical presence, such as reading, shipping, and receiving TLDs, as well as irradiation of standards and controls. For radiation dosimetry service staff, whose work requires being present onsite, we established morning and afternoon shifts with a 30-minute gap in between to ensure no overlap. Other staff work from home 60% or 100% of the time.

We implemented several other safety measures for our staff, including limiting building access to approved essential workers, limiting building access to a single point of entry, COVID-19 screening at entry that includes measuring temperature and answering screening questions, regular disinfection of high-touch surfaces, and the mandatory wearing of face masks. We also require social distancing at all times.

Accredited dosimetry calibration laboratory operation during COVID-19 pandemic

The MD Anderson Accredited Dosimetry Calibration Laboratory (ADCL) has faced serious obstacles during the COVID-19 pandemic. Its operations are essential to providing calibrations for radiation therapy facilities around the world. However, our facility is located in the middle of the radiation therapy 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 laboratory was even forced to suspend calibration activities.

Clinical research during 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 MD Anderson 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 and face-to-face interaction 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 trials 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 remained operating normally, reviewing and approving new protocols as usual but working remotely through WebEx.

Education of residents and trainees

Our trainees are still engaged with computer-based research projects while access to laboratory 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 takes 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 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 who seek to understand complex radiation oncology processes and their ramifications in radiation oncology. We must communicate effectively with all the teams we support, and strategically coordinate every
aspect of how to facilitate radiation therapy treatment during the COVID-19 crisis. Daily conversations with the 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 made available by the American Association of Physicists in Medicine and the 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.\textsuperscript{14,15} We should set manageable departmental goals that are feasible given departmental resources (Table 1). 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.

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