



Proton Therapy in a Pandemic: An Operational Response to the COVID-19 Crisis

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Introduction

As an academic proton therapy center, our current challenge is to balance delivery of cutting-edge cancer treatments with appropriate mitigation and management of COVID-19 risk for both staff and patients. To facilitate communication across centers about best practices during these challenging times, this piece will outline our operational response to the pandemic caused by the coronavirus SARS-CoV-2 [1], with specific consideration of issues facing out-of-hospital proton therapy centers. This will also provide a starting point for response to future disasters.

Institutional and Departmental Response

Our approach was based on the concurrent goals of protecting our patients and staff from SARS-CoV-2 infection while continuing to deliver high-quality proton therapy. To meet these objectives, we undertook the following steps in coordination with the Department of Radiation Oncology at MD Anderson; these have been described in detail elsewhere [2].

- 1) Enacted a zero-visitor policy, with exceptions for adults with neurocognitive impairments and pediatric patients.
- 2) Established entry-point control with separate patient and employee screening checkpoints at the entrance to the proton therapy center (PTC).
- 3) Promoted hand hygiene and provided surgical masks to be worn by all patients, visitors, and staff while in the building.
- 4) Enabled social distancing by implementing work-from-home strategies for administrative staff, physicists, dosimetrists, nurses, and radiation therapists (RTTs).
- 5) Developed telemedicine workflows for clinical visits, patient education, and obtaining consent.
- 6) Enacted a requirement for established patients coming from outside Texas to self-quarantine for 14 days before clinic visit, simulation, or initiation of therapy, and to continue to self-quarantine while under treatment.
- 7) Enacted a requirement for new patients coming from outside Texas to have a negative test result for COVID-19 before proceeding with the first appointment.

PTC-Specific Response

The PTC has 2 passive scatter gantries, 1 scanning beam gantry, 1 fixed beam line, and 1 photon linear accelerator [3]. Our routine hours of operation are 4 AM to 12 AM, treating

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20 hours per day. Our typical patient mix includes patients with prostate cancer, head and neck cancers, pediatric malignancies, and thoracic tumors. This complex patient population and the unique treatment workflows at the PTC introduced several additional challenges into our pandemic response.

Patient Care Concerns

The first priority from a patient care perspective was to reduce our treatment volume as much as possible to prepare for the potential of a forced staff reduction due to COVID-19 exposure or illness and the subsequent requirement for staff to self-quarantine. From February 24 to March 20, 2020, there were 32 new patient evaluations or consults at the PTC; this decreased to 23 from March 23 to April 17, 2020. In addition, 118 follow-up visits were canceled, delayed, or performed via telephone. As of April 17, 2020, follow-up visits could be performed using the Zoom platform built into Epic, allowing for true telemedicine within the context of the electronic medical record. As of April 24, 2020, this capability was extended to include consults. The role of telemedicine will likely expand exponentially over the coming months and years to overcome global and domestic travel bans as well as expected concerns and fears related to COVID-19 exposure while flying.

With these interventions, the number of patients treated at the PTC with proton therapy decreased from 116 on March 2 to 78 on March 31, 2020, a 33% reduction in clinical volume. New patients who started treatment tended to have life-threatening tumors, such as head and neck tumors [4], thoracic tumors, and as pediatric malignancies [5] where treatment delay would likely have a negative effect on outcomes. These were also patients for whom radiation therapy could not be deferred or delayed without compromising clinical outcomes. Further, many of our patients were on therapeutic clinical trials and could not be transitioned to alternative treatments without committing major protocol deviations or substantially compromising care.

This patient mix has generated unique clinical questions. Because many of our patients are children, they require a parent or other caregiver to attend treatments with them. Occasionally, this has resulted in the difficult situation where the patient passes the front door screening for COVID-19 symptoms but the parent or caregiver does not. These challenging episodes have required exceptionally compassionate clinical decision making to resolve. Also, some of our pediatric patients are referred directly to our center for treatment from other hospitals. Navigating COVID-19-related algorithms has required extensive coordination with referring hospitals that have different COVID-19 screening policies.

Our PTC is a freestanding building on the south campus of the institution, approximately 1 mile from the main hospital. This physical distancing has yielded some benefits during this pandemic. First, our patients are geographically separated from the majority of cancer patients at the institution. This physical distancing helps protect the most at-risk patients in the hospital, especially those who are immunocompromised and may be at higher risk for complications from COVID-19. The PTC also does not have on-site SARS-CoV-2 testing. All PTC patients and employees who are persons under investigation (PUIs) for SARS-CoV-2 infection are sent to an off-site satellite for SARS-CoV-2 testing. This helps minimize exposure risk to our patients and staff at the PTC. The PTC also does not routinely provide emergent radiation therapy; patients who require emergent radiation treatment are seen at the main hospital building. This reduced acuity of care eliminates the potential situation of a PUI needing emergent radiation at the PTC.

PUIs undergoing proton therapy have had their treatment held until test results negative for SARS-CoV-2 were obtained. From March 21 to April 23, 2020, 11 PTC patients had SARS-COV-2 testing; none of these patients was positive. Seven of these patients had no delay in treatment while awaiting testing results; 4 patients were delayed by 1 day. Future proton therapy patients confirmed positive for SARS-CoV-2 will have their treatment held and will be re-planned for treatment with intensity-modulated radiation therapy on a dedicated linear accelerator at a separate location if deemed a medical emergency; otherwise, they will resume therapy after recovery from illness [2].

Staff Management

Experience from other centers in areas of high community spread [6] have suggested that maintaining adequate RTT staffing would be the most critical component of maintaining our ability to deliver proton therapy during the pandemic. In mid March, we developed a phased model of RTT staffing that would allow us to gradually ramp down the number of RTTs at the PTC (Table). Because of our decreased patient volume, we were able to decrease our treatment hours to 6 AM to 10 PM, a 20% reduction from our normal treatment times of 4 AM to 12 AM. We also reduced the hours of computed tomography/magnetic resonance imaging simulation to 8 AM to 12 PM, a 50% reduction in the number of our typical simulation slots. As of April 20, 2020, we are operating at phase 3 of our staffing model (Table). If pandemic conditions in Houston worsen over the coming weeks, we are prepared to further decrease our operations and staffing numbers. Using this model in reverse will also allow us to gradually ramp up clinical activity as acute pandemic conditions transition to a prolonged state of endemic COVID-19. In addition to

Table. Proton therapy center pandemic staffing model.

Phase	Operations	RTT staffing	% RTT workforce
0	Full operations	26 RTTs 2 MR technicians	100
1	Full operations	22 RTTs 2 MR technicians	86
2	Full treatment operations Reduced CT/MRI simulation schedule to 50%	22 RTTs 1 MR technicians	82
3	Reduced proton treatments to 0600–2200 Reduced photon treatments 1400–1600 Reduced CT/MRI simulation schedule to 50%	19 RTTs 1 MR technicians	71
4	Reduced proton treatments to 0600–2200 No photon treatments No CT/MR simulation	17 RTTs	61
5	Markedly reduced proton treatments to treat only pediatric patients, young adults, and small subset of high-risk patients. Re-plan and transition remaining patients to IMRT elsewhere. No CT/MR simulation	10 RTTs	36
6	No activity. Re-plan and transition all patients to IMRT elsewhere.	0 RTTs	0

Abbreviations: CT/MRI, computed tomography/magnetic resonance imaging; IMRT, intensity-modulated radiation therapy; MR, magnetic resonance; RTT, radiation therapist.

reducing staffing needs, RTTs were scheduled as much as possible to minimize cross coverage across different gantries. In response to the decreased scheduling demands and to further enable physical distancing among the staff, RTTs were also rotated in a 3-week-on-site, 1-week-off-site schedule.

To maintain our staff’s engagement with decreased on-site responsibilities, administrative and research staff were redeployed as front-door screeners at the PTC and elsewhere within the institution. This yielded a consistent pool of staff members to maintain 24-hour coverage of front-door screening sites.

The physics tasks associated with patient treatment and machine quality assurance activities were continued at the same level as before the pandemics. All dosimetrists have been working remotely from home. During patient treatment hours, only 1 physicist is required to be on-site at a time, 1 for the morning/day shift and another for the afternoon/evening shift. All other physicists are working remotely from home and are available through audio/video conference; if necessary, off-site physicists are dispatched to the PTC. In addition, a physics assistant is on-site for most of the treatment hours, typically 1 from 6 AM to noon and another from 11 AM to 6 PM. If multiple physics staff members need to work in the same area, social distancing and facial masks are required. The machine shop and maintenance team are operating normally with an emphasis on hand hygiene, social distancing, and wearing masks. Contract workers from the accelerator vendors are treated the same as our own employees.

As of April 24, 2020, the PTC has had 1 employee self-quarantined due to a trip to Italy before the onset of federal travel restrictions; this employee was never symptomatic and returned to work after 14 days of quarantine. To date, there have been no symptomatic staff members at the PTC and no employees who have tested positive for SARS-CoV-2.

Because the PTC is an outpatient center, we have an on-site Code Blue team composed of physicians and nurses drawn from the PTC staff. Due to the pandemic, all members of the Code Blue team have been fitted for N95 masks that are readily available in the event of a code event, as certain procedures, such as bag ventilation and intubation, are considered aerosol-generating procedures [7]. Additional personal protective equipment, including gowns and eye protection, has also been made available on every crash cart for every team member.

Conclusions

The oncology community continues to advance our understanding of SARS-CoV-2 infection in cancer patients, many of whom are immunocompromised. Several essential questions remain, such as the effect of SARS-CoV-2 on specific malignancies, appropriate timing to resume oncologic therapy in a patient recovering from COVID-19 infection, and the role of SARS-CoV-2

antibodies during and after infection. Until data are available to provide further clarity in these unique times, risk mitigation strategies remain our most important tool to enable us to continue providing proton therapy care for our cancer patients.

ADDITIONAL INFORMATION AND DECLARATIONS

Conflicts of Interest: The authors have no relevant conflicts of interest to disclose.

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