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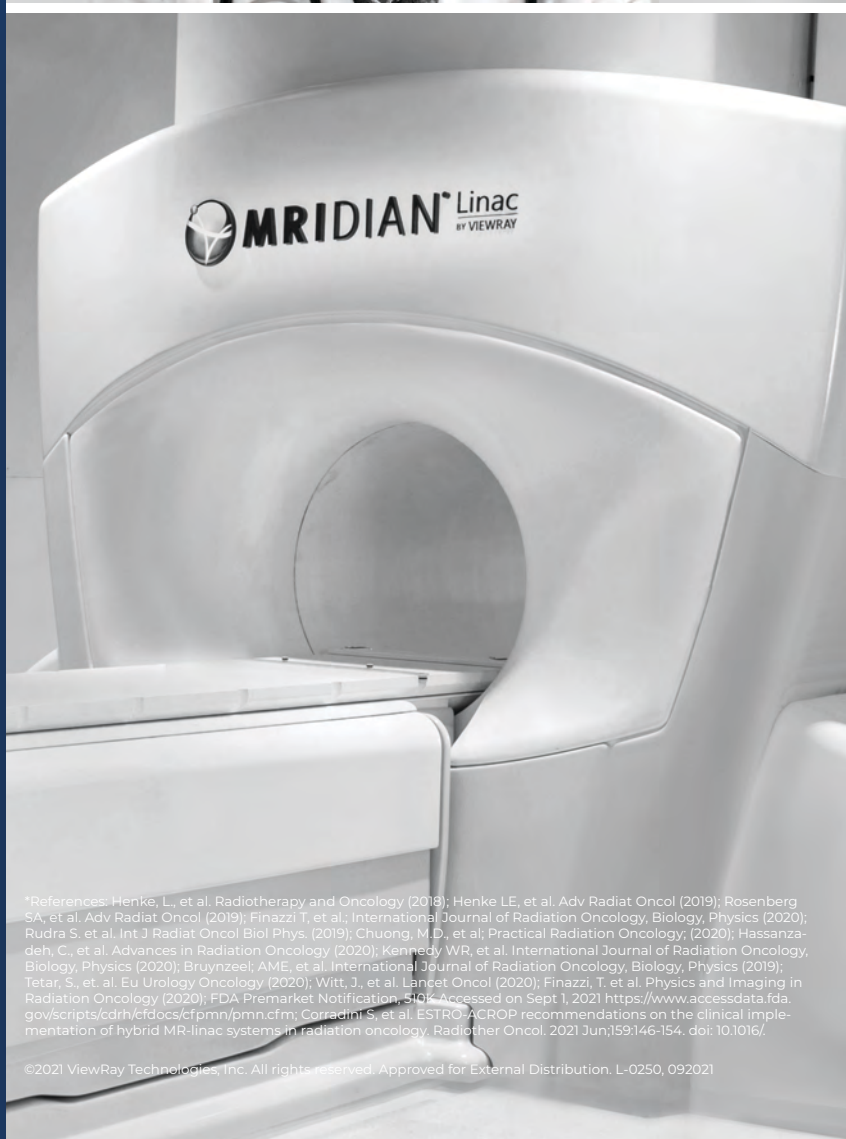

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COVID-19 Continued: Successes, Setbacks and Effects on Radiation Oncology

John Suh, MD, FASTRO, FACR

As 2021 draws to a close, we have much to be thankful for: a new generation of COVID-19 treatments on the horizon, very low death rates for fully vaccinated adults under 50, booster shot eligibility, and numerous other strides in our continued battle against the coronavirus. Although we have made progress over the past two years, the pandemic and its repercussions are far from over. Unvaccinated people remain at considerable risk of serious effects. The Omicron variant is ushering in a new wave of uncertainty. And the mental, physical, and financial tolls are staggering, particularly among cancer patients.

Key to alleviating this ongoing distress on patients, providers, and practices is a better understanding of the economic ramifications of COVID-19 on radiation treatment delivery, as described in an outstanding review article titled *The Economic Impact of the COVID-19 Pandemic on Radiation Oncology Practice.* The authors examine COVID's fallout on core radiation oncology activities such as departmental management and evidence generation, and the impact on surgery and systemic treatments. Building this knowledge will help steer evidence-based resource allocation and identify creative opportunities to support value-based care in times of ambiguity.

We are also pleased to feature the thought-provoking research article, *Formalized Mentorship in Radiation Oncology in the COVID Era: American College of Radiation Oncology Experience*. This article summarizes the results and effectiveness of the ACRO Mentorship Program 2020-2021 at a time when unique challenges such as physical distancing, financial losses, and competing priorities remain widespread.

An additional article addressing COVID in radiation oncology is *Radiation Recall After the COVID-19 Vaccine: Two Cases and a Review of the Literature*. This timely report examines radiation recall postmastectomy dermatitis and radiation recall proctitis in two patients after their COVID-19 vaccination, and describes potential effects of the vaccine to consider when counseling patients.

In addition to our COVID lineup, we are pleased to offer the SA-CME-accredited article, *Stereotactic Body Radiation Therapy (SBRT) vs Stereotactic Ablative Radiation Therapy (SABR): Does Terminology Differentiate Treatment Intent in Metastatic Cancer?* In this review of prospective trials and protocols on stereotactic radiation therapies for metastatic disease, the authors determine whether the terms SBRT and SABR are being used differentially according to treatment intent and propose a distinct definition of each.

Also featured are two other noteworthy and comprehensive case reports, one detailing the use of MR-guided radiation therapy for oligometastatic central lung cancer, and the other describing the rare phenomenon of delayed radiation-related transient, symptomatic cerebral demyelination following treatment of a secretory pituitary macroadenoma.

Finally, the Technology Trends department highlights new and updated technologies featured at ASTRO 2021, and the Resident Voice editorial stresses the critical need for advocacy during residency (and beyond), especially in light of the recent unprecedented changes in radiation therapy supervision requirements, major proposed cuts in Medicare reimbursement, and the Radiation Oncology Alternative Payment Model, which has been delayed until 2023. We look forward to bringing you more on this topic in our March issue.

Until then, please enjoy our December edition and have a safe and joyful holiday season! We are immensely grateful for your support over these last 10 years, especially given the complexities and challenges of COVID-19. We wish you a 2022 full of peace, promise, happiness, and growth!

Stereotactic Body Radiation Therapy (SBRT) vs Stereotactic Ablative Radiation Therapy (SABR): Does Terminology Differentiate Treatment Intent in Metastatic Cancer?

Description

The authors review published prospective trials and protocols on stereotactic radiation therapies for metastatic disease to determine whether the terms SBRT and SABR are being used differentially based on intent of treatment, defined by primary study outcome, and propose a distinct definition of each.

Learning Objectives

Upon completing this activity, the readers should be able to:

- appreciate the importance of clear and consistent terminology to clarify treatment intent in metastatic disease, and
- adopt the use of the term stereotactic ablative radiation therapy (SABR) in the setting of metastatic disease for treatments with ablative intent and adopt stereotactic body radiation therapy (SBRT) for treatments with palliative intent.

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Target Audience

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- Related Oncology Professionals

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Stereotactic Body Radiation Therapy (SBRT) vs Stereotactic Ablative Radiation Therapy (SABR): Does Terminology Differentiate Treatment Intent in Metastatic Cancer?

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Stereotactic body radiation therapy (SBRT) or stereotactic ablative radiation therapy (SABR) has an evolving role in the treatment of primary and metastatic cancer. Loosely defined in the United States as radiation therapy that delivers high-dose radiation within a single or very few (generally ≤ 5) fractions, various terms have been used interchangeably to describe stereotactic radiation therapies with no clear-cut terminology documented.[1] The term SABR emerged in 2010 as it was thought to more accurately describe the dose intensity of the treatment vs SBRT, and it was proposed that the term be used instead of SBRT.[2] Several trials on stereotactic radiation therapies have since been developed and published, yet the discourse surrounding preferred terminology within the literature remains unclarified.

Previous work has shown that patients undergoing treatment for metastatic cancer often do not have an accurate understanding of the intent of therapy, and that this misunderstanding may influence their decisions about further treatments.[3-5] In the setting of metastatic disease, stereotactic therapies may be administered with intent to either ablate disease or provide palliation. Confusion results from the interchangeable use of the term SABR, which implies ablative intent, and SBRT, which is agnostic toward treatment intent. We anticipate that clarification of this terminology could help avoid confusion for patients and physicians, ultimately improving communication with patients undergoing treatment for metastatic disease. Herein, we review published prospective trials and protocols on stereotactic radiation therapies for metastatic disease to determine whether the terms SBRT and SABR are currently being used differentially based on intent of treatment, defined by primary study outcome, and propose a distinct definition of each.

Evidence Review

We conducted a narrative review of the literature to identify and summarize prospective trials and protocols that investigated the use of stereotactic radiation therapies for patients with metastatic disease. A PubMed query was conducted (search query outlined in **Supplementary Text 1** available with the online version of this article at www.appliedradiationoncology.com). Trials and protocols were included if: 1) they evaluated the use of radiation therapy directed toward visceral or bone metastases, 2) the intervention included stereotactic radiation therapy, 3) they assessed a primary outcome related to treatment response, disease control, or quality of life, 4) they used a prospective study design, and 5) they were published between January 1, 2010 and September 5, 2020. Studies were excluded if 1) they were phase 1 or pilot studies, 2) they represented a secondary analysis of a previously published trial, or 3) they included pediatric patients. A hand search of the gray literature included relevant professional organization websites as well as ClincialTrials.gov.

We categorized the trials we identified based on terminology used (SBRT vs SABR), and whether they were single arm or randomized.

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Disclosure: Dr. Lapen and Mr. Mathis are in a research fellowship funded by grants for research and education related to eContour.org, an educational website for radiation oncology professionals. Dr. Tsai is a consultant with Varian. Dr. Gillespie is a co-founder of eContour.org. Dr. Yang has no disclosures. No part of this article has been previously published elsewhere. This work is supported by a National Comprehensive Cancer Network (NCCN) Pfizer grant to Enhance Academic-Community-Patient Relationships in Metastatic Breast Cancer, and a P30 Memorial Sloan Kettering Cancer Center Core Grant (CA008748).

We also categorized the primary endpoint in each study based on treatment intent, either as "tumor control" if related to local control, progression-free survival, or overall survival; or "palliation" if related to relief of symptoms. Inclusion and categorization of each study was determined by 2 reviewers (KL, NJM), and discrepancies were resolved by a third reviewer (EFG). Fisher's exact test was used to assess the association between trial terminology and primary endpoint category.

Findings

Overall, 48 trials met eligibility criteria, of which 40% (n = 19) had published their results,[6-25] and 60% (n = 29) were ongoing. Published studies are listed in **Table 1** and **Table 2**. Eight trials (17%) primarily used the term SABR, 36 (75%) used the term SBRT, and 4 (8%) used a different term to describe the intervention. Nineteen trials (40%) were randomized. Overall, 75% (n = 36) and 25% (n = 12) of the trials assessed a primary outcome categorized as tumor control or palliation, respectively. Primary outcome did not differ based on intervention terminology ($P = 0.41$). We also assessed the use of terminology in published randomized trials only, speculating that these are usually the most influential publications. This subset includes 8 studies, of which 4 use the term SBRT, 3 use the term SABR, and 1 uses local consolidative therapy. Of note, within this cohort, all studies assessing palliative endpoints used the term SBRT, and 3 of 5 studies assessing tumor control used the term SABR.

Discussion

Recent evidence from randomized clinical trials has shifted the way in which we approach the treatment of patients with limited metastatic disease, expanding indications for the use of stereotactic radiation therapy with curative intent.[26] An updated analysis of the phase 2 SABR-COMET (NCT01446744) trial reported a median 22-month increase in overall survival at 5 years with SABR in patients with controlled primary yet oligometastatic disease compared to standard of care.[11] Other randomized trials that have investigated the effect of stereotactic therapies on outcomes related to survival and disease progression include Gomez et al (NCT01725165),[6,7] Iyengar et al (NCT02045446),[9] and the ORIOLE trial (NCT02680587).[12] The trials published by Gomez et al and Iyengar et al are both phase 2 randomized trials that showed prolonged progression-free survival in patients with oligometastatic non-small-cell lung cancer who received SABR compared with maintenance therapy. The recently published ORIOLE trial showed lower rates of disease progression at 6 months in patients with oligometastatic prostate cancer who received SABR compared with observation. Collectively, these trials suggest that SABR/SBRT may effectively prolong progression-free and overall survival in patients with oligometastatic disease, typically defined as disease with limited metastases to 1 or 2 other regions of the body outside of the site of primary disease.[27]

While stereotactic radiation therapy has a promising role in the curative treatment of patients with oligometastatic disease, it also has an emerging role in the palliation of symptoms caused by metastatic cancer. Prospective studies have shown that SBRT is feasible in the palliation of bone metastases and may reduce cost and the amount of time patients spend receiving treatment.[28,29] A recent randomized trial conducted at The University of Texas MD Anderson Cancer Center (NCT02163226) found that the use of SBRT vs standard multifraction radiation therapy for the treatment of symptomatic bone metastases resulted in higher rates of pain response.[21] An additional phase 2 randomized trial published by Sprave et al (NCT02358720) found a more rapid and durable pain response with SBRT compared with multifraction conventional palliative radiation therapy (30 Gy in 10 fractions) for patients with spinal bone metastases.[20] Although further evidence is needed before the efficacy of SBRT for the palliative treatment of bone metastases is fully understood and recommended for use in routine practice, there are technical advantages to this modality, and its use in the palliative setting has been increasing.[30,31]

Despite the proposal to switch from the term SBRT to SABR in 2010,[2] several trials still use the term SBRT. The results of our literature review demonstrate no correlation between terminology and treatment intent amongst all studies, but when including only the most influential publications (randomized trials), there seems to be a selective choice in terminology based on the endpoint. Given these findings, it may be reasonable to suggest that the term SABR should refer to a type of stereotactic therapy that is delivered with curative intent for patients with metastatic disease, and that it is not synonymous but rather falls under the more encompassing term SBRT in this setting. We recognize that for most clinicians, the terms SBRT and SABR are often considered interchangeable, despite prior calls to standardize terminology. The term SABR represents a newer name for an already existing treatment and is thought to more accurately describe the dose intensity in addition to its aesthetic benefits. Nonetheless, the interchangeable use of the terms in clinical practice, despite the preference for the term SABR when publishing randomized trials aimed at tumor control for metastatic disease, likely creates unnecessary confusion.

Conclusion

Evidence is evolving on the use of stereotactic radiation therapies for both palliative and ablative treatment in the metastatic disease arena. With

Table 1. Published Trials Assessing the Use of Metastasis-Directed Stereotactic Radiation for Tumor-Control Endpoints

STUDY NAME	YEAR	ELIGIBLE PATIENTS	PHASE	INTERVENTION ARM	CONTROL ARM	PRIMARY ENDPOINT	STATISTICALLY SIGNIFICANT?*	TERM USED	JOURNAL	PMID
Randomized										
Gomez, et al NCT03410043	2016	NSCLC with 1-3 metastases, response to systemic therapy	2	Local consolidative therapy (RT or resection)	Maintenance treatment	Progression-free survival	Yes	n/a	Lancet Oncol/J Clin Oncol	27789196/ 31067138
Ost, et al STOMP/ NCT01558427	2017	Recurrent prostate cancer with 1-3 extracranial metastases	2	SBRT or surgery to metastases	Surveillance	ADT-free survival	Yes	SBRT	J Clin Oncol	29240541
Iyengar, et al NCT02045446	2018	NSCLC with up to 5 metastases	2	SABR plus maintenance chemotherapy	Maintenance chemotherapy	Progression-free survival	Yes	SABR	JAMA Oncol	28973074
Palma, et al SABR-COMET/ NCT01446744	2019	1-5 metastatic lesions	2	SABR to metastases	Palliative RT	Overall survival	Yes	SABR	Lancet/ J Clin Oncol	30982687/ 32484754
Phillips, et al ORIOLE/ NCT02680587	2020	Recurrent hormone-sensitive prostate cancer with 1-3 asymptomatic metastases	2	SABR to metastases	Observation	Progression at 6 months	Yes	SABR	JAMA Oncol	32215577
Single-Arm										
Collen, et al	2014	Oligometastatic NSCLC with 1-5 sites	2	10 fraction SBRT to all disease sites	None	Complete metabolic response	n/a	SBRT	Ann Oncol	25114022
Nuyttens, et al NTR1788	2015	Oligometastases to lung	2	3 fraction or 1 fraction SBRT to lung metastases	None	Local control	n/a	SBRT	Int J Radiat Oncol Biol Phys	25636758
Scorsetti, et al	2015	Colorectal cancer with 1-3 liver metastases	2	3 fraction SBRT	None	Local control	n/a	SBRT	J Cancer Res Clin Oncol	25245052
Trovo, et al CRO 2012-47	2018	Oligometastatic breast cancer with 1-5 sites	2	SBRT or IMRT to metastases	None	Progression-free survival	n/a	SBRT	Radiother Oncol	28943046
Arrieta, et al NCT02805530	2019	NSCLC with 1-5 metastases	2	Radical consolidative therapy	None	Overall survival	n/a	n/a	Lung Cancer	30885354
Petty, et al NCT01185639	2019	NSCLC with 1-5 metastases, response to systemic therapy	2	Consolidative radiation therapy	None	Progression-free survival	n/a	n/a	Int J Radiat Oncol Biol Phys	30003996
Weiss, et al NCT01573702	2019	NSCLC on EGFR TKI with 1-5 progressive sites	2	Stereotactic radiation	None	Progression-free survival	n/a	n/a	Cancer Treat Res Commun	30852467
Redmond, et al NCT01752036	2020	Spinal metastases having undergone surgery	2	Postoperative 5 fraction SBRT	None	Local control	n/a	SBRT	Int J Radiat Oncol Biol Phys	31628959

*Table of published randomized clinical trials assessing the use of stereotactic radiation therapy for metastatic disease with endpoints assessing tumor control. Trials are organized by randomized vs single-arm studies. *Statisical significance refers to whether a difference was demonstrated between intervention and control arms with regard to the primary endpoint.*
Key: NSCLC = non-small-cell lung cancer, RT = radiation therapy, SBRT = stereotactic body radiation therapy, ADT = androgen deprivation therapy, SABR = stereotactic ablative radiation therapy, IMRT = intensity-modulated radiation therapy

Table 2. Published Trials Assessing the Use of Metastasis-Directed Stereotactic Radiation for Palliative Endpoints

STUDY NAME	YEAR	ELIGIBLE PATIENTS	PHASE	INTERVENTION ARM	CONTROL ARM	PRIMARY ENDPOINT	STATISTICALLY SIGNIFICANT?*	TERM USED	JOURNAL	PMID
Randomized										
Sprave, et al NCT02358720	2018	Painful spinal metastases	2	Single-fraction SBRT	10-fraction conventional RT	Pain response	No	SBRT	Radiother Oncol	29843899
Nguyen, et al NCT02163226	2019	Painful bone metastases	2	Single-fraction SBRT	10-fraction conventional RT	Pain response	Yes†	SBRT	JAMA Oncol	31021390
Pielkenrood, et al VERTICAL/ NCT02364115	2021	Painful bone metastases	2	Standard SBRT	Standard conventional RT	Pain response	No	SBRT	Int J Radiat Oncol Biol Phys	33333200
Single-Arm										
Wang, et al NCT00508443	2012	Stable spinal metastases	1-2	3-fraction SBRT	None	Frequency and duration of complete pain relief	n/a	SBRT	Lancet Oncol	22285199
Guckenberger, et al NCT01594892	2018	1-2 painful spinal metastases	2	5- or 10-fraction SBRT	None	Pain response	n/a	SBRT	Cancer	29499073
Wardak, et al NCT00855803	2019	Painful spinal metastases	2	Single-fraction SABR plus vertebroplasty	None	Pain response	n/a	SABR	Int J Radiat Oncol Biol Phys	30684664

*Table of published randomized clinical trials assessing the use of stereotactic radiation therapy for metastatic disease with endpoints assessing palliation. Trials are organized by randomized vs single-arm studies. *Statistical significance refers to whether a difference was demonstrated between intervention and control arms with regard to the primary endpoint.*
†Study was powered to show noninferiority but did note a significant difference between arms in terms of pain response. Key: SBRT = stereotactic body radiation therapy, RT = radiation therapy, SABR = stereotactic ablative radiation therapy

this split in the paradigm, there is an important opportunity to improve clarity surrounding treatment intent by using consistent terminology. Based on our review of published randomized control trials and protocols, the term SABR is more commonly used in the literature for oligometastatic disease in which stereotactic radiation therapy is administered with curative intent. In contrast, the term SBRT is more widely used and encompasses radiation therapy delivered with both palliative and curative intent to patients with incurable metastatic disease and oligometastatic disease, respectively. Therefore, we propose that a distinction be made and that the term SABR should be used in reference to stereotactic therapies delivered with curative intent for patients with oligometastatic disease, while the term SBRT should be used to describe radiation therapy delivered with palliative intent to sites of metastases regardless of overall disease burden. We believe this distinction will reduce confusion in routine practice and ensure consistency in the publication of research on a single technique used for two distinct purposes.

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The Economic Impact of the COVID-19 Pandemic on Radiation Oncology Practice

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The coronavirus disease 2019 (COVID-19) has caused economic disruption across the health care system. While much of the literature has focused on the direct costs of preventing and treating COVID-19, the pandemic has also affected the cost of delivering care across the cancer continuum, including in radiation oncology.[1] The economics of radiation therapy delivery are impacted by changes in the direct and indirect costs of delivering treatment, reimbursement structures, changes in demand and utilization, and the expected value of treatment. The COVID-19 pandemic has affected these factors on multiple levels: the number of patients seen at cancer centers has been reduced, additional safety procedures have been introduced, the availability and training of personnel has been affected, patient behavior has been influenced, and clinical practice has changed.[2-4]

The economic impact of COVID-19 can be evaluated at different stages of the treatment pathway. The American Association of Physicists in Medicine (AAPM) previously developed a process map that outlines the workflow of each step in radiation oncology practice, which includes the initial patient assessment, treatment planning and delivery, quality assurance, and post-treatment evaluation.[5] This process map has been previously applied to characterize the resource requirements and costs of radiation therapy using an activity-based costing approach. The Health Economics in Radiation Oncology program of the European Society of Radiotherapy and Oncology (ESTRO-HERO) adopted this workflow into their time-driven activity-based costing model and organized the activities needed to deliver radiation therapy along 3 activity levels defined as "core" radiation oncology services, "support" services such as departmental management and quality assurance, and activities "beyond" the radiation therapy care pathway such as participation in the multidisciplinary team, long-term follow-up, and survivorship.[6]

Using the AAPM process map and the ESTRO-HERO costing model as a guide,[6] we comprehensively evaluate the economic impact of COVID-19 on radiation oncology from the perspective of the patient, provider, and health care system on core, support, and beyond radiation oncology activities. Although the economic crisis caused by the COVID-19 pandemic was initially thought to be V-shaped with a quick recovery, the pandemic has demonstrated the potential for a W-shape, with relapse due to further lockdowns, or L-shape, with a more permanent loss of output.[7] Understanding the economic impact of COVID-19 on the practice of radiation oncology is critical to mitigate ongoing perturbations on patients, providers, and clinical practices due to the current pandemic as well as future health care shocks, to ensure evidence-based resource allocation, and to identify opportunities for innovation to support value-based care.

Economic Impact on Core Radiation Oncology Activities

Core activities in radiation oncology can be grouped into 3 key activity areas along the patient care pathway: 1) patient diagnosis and assessment, 2) treatment planning and delivery, and 3) post-treatment management.

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These activity areas have been adapted and broadened from the original ESTRO-HERO framework to include activities directly impacting radiation oncologists' time, costs, and reimbursement. Each of these activity areas is affected by changes in capital and operational costs as well as reimbursement. Capital costs include the upfront investment in equipment, facilities, and training of personnel, whereas operational costs are related to the utilization of equipment (treatment-related costs and quality assurance), staffing (including continuing education of personnel) and maintenance (including building and machinery maintenance and overhead). The impact of COVID-19 on cost and reimbursement at each of these time points is shown in **Table 1**. Although costs and reimbursement should be linked, costs reflect the quantity and quality of consumed resources, while reimbursement reflects society's agreement to pay for a health care service and is negotiated between providers and payers.[8] The structure and type of reimbursement systems vary between countries, with differences in the components of radiation treatment that are eligible for reimbursement, the fees paid for treatment techniques, fractionation schedules, and indications.[9]

Patient Diagnosis and Assessment

Screening and diagnostic services for cancer were significantly reduced over the course of the COVID-19 pandemic due to increased demands on the health care system as well as public health messaging to seek care only when urgently required to minimize contact and mitigate risk.[10-13] Patient behaviors also changed, with many postponing or forgoing screening or diagnostic investigations due to fear of contracting COVID-19. A cross-sectional study from January 2018 to March 2021 in the US found that the number of weekly new cases of breast, prostate, colorectal, pancreatic, gastric, and esophageal cancer declined by 46.4% overall during the first year of the pandemic, ranging from 24.7% for pancreatic cancer to 51.8% for breast cancer.[14] This combination of reduced availability and demand for screening and diagnostic services had a significant downstream impact on demand for radiation therapy, the complexity of treatment, and on provider and facility revenue.

A survey by the American Society for Radiation Oncology (ASTRO) in April 2020 of 222 leaders in academic and community practices in the US on the initial impact of the COVID-19 pandemic found that 81% of practices reported a reduction in referrals and that, on average, practices reported treating 68% of their usual volume (range: 10% to 95%).[15] Practices also reported some decrease in monthly revenue, with 71% of practices estimating revenue declines of 20% or more. In specialized centers, reduced patient flow and postponed treatments had a particularly negative impact on the return on investment of recently introduced high-cost interventions such as MR-linac or proton-beam radiation therapy, as their cost could not be buffered by other treatments already established in the department.[2,15] Some departments in the US noted a decline in billable activity of up to 35%, driven by a significant decline in the demand for consultation and treatment.[16] By the end of 2020, Medicare physician fee schedule services had declined by 8% overall, compared with the same period prior to the pandemic.[17]

The ASTRO survey was also sent to European department heads in May 2020 and similar findings were observed, with 60% of clinics reporting a decline in patient volume.[18] In February 2021, after 1 year of the COVID pandemic, ESTRO repeated the survey and noted an improvement in demand for treatment, but a persistent decrease in 53% of the centers surveyed in patient volume compared with before the pandemic.[18] In Latin America, initial consultations were reduced by 28% to 38%, with a corresponding reduction in pathology (6% to 50%), cancer surgery (28% to 70%), and chemotherapy (2% to 54%). Reductions in radiation therapy use were noted in Brazil, Chile and Peru (8% to 31%).[19]

Staffing shortages during the pandemic compounded the impact of fluctuating patient volumes. A survey of radiation therapy department managers from Canada and Norway found that 25% and 39% of departments, respectively, experienced shortages, which were partially due to staff redeployment.[20] In Africa, the highest rates of staff shortages were in low-income countries as compared with middle-income countries, which were driven by fear of contracting the virus and inadequate personal protective equipment (PPE).[21] In the US, the Coronavirus Aid, Relief, and Economic Security (CARES) Act that was signed into law in March 2020 was intended to offset the loss of revenue of hospitals and clinics and avoid layoffs.[22] However, the extent to which this was successful in mitigating staff turnover has not yet been quantified.

In order to further limit interruptions in the delivery of radiation oncology services while maintaining physical distancing, the use of telehealth rapidly increased during the pandemic.[23-25] Many radiation oncology services were not previously reimbursed, or adequately reimbursed, through virtual platforms, and the deregulation of telehealth services and the introduction of new temporary fee codes were used to facilitate virtual care.[23,26,27] Although in-person visits increased over time with increasing vaccination rates, the demand for virtual options by both patients and providers has prompted

Table 1. Impact of COVID-19 on Radiation Therapy Activities Using the ESTRO-HERO Costing Framework

ESTRO-HERO CATEGORY	PATHWAY ELEMENT	COVID-19 IMPACT ON RADIATION ONCOLOGY SERVICES	PROVIDER COSTS	PAYER COSTS
Core	Patient Diagnosis and Assessment	Decreased screening and diagnosis Delayed presentation Pivot toward virtual care	Overhead costs for virtual care platforms Increased costs for cleaning and PPE Decreased reimbursement due to lower volumes	New billing codes required for virtual care
	Treatment Planning and Delivery	Treatment delays due to competing health system demands and the need to minimize exposure risk Increased cleaning/PPE procedures Rapid adoption of new treatment protocols (eg, hypofractionation)	Increased operational costs from enhanced cleaning and PPE during treatments Altered personnel safety needs, availability, and costs Decreased total reimbursement from lower treatment volumes	Altered case mix and treatment protocols impacting reimbursement in fee-for-service systems Decreased costs with shorter fractionation schedules if reimbursement is tied to the number of fractions or if disinvestment is possible
	Post-Treatment Follow-Up and Support	Reduced access to post-treatment screening and follow-up care	New models of care with potential for lower overall costs	Decreased costs due to lower post-treatment volumes in fee-for-service environment
Support	Department Management	New SOPs for patient safety, staff safety, PPE, treatment protocols Additional personnel need to manage new COVID-related planning Management of staff burnout	Overhead costs associated with generating new SOPs and virtual workflow Availability of bonuses to supplement income	Staffing shortages leading to higher payer costs due to increased salary and benefit requirements
	New Technology, Research and Evidence Generation	Altered research funding availability Lack of time to implement new technology/techniques Reduced clinical trial enrollment and preclinical cancer research (diminished progress) New data sources	Staff layoffs due to decreased research output	New data sources for health technology assessment to inform future decisions on reimbursement
Beyond	Multidisciplinary Care	Reduced surgical volumes/delayed surgeries Delayed surgery prompting use of RT as a treatment bridge Paused chemotherapy treatments Use of systemic therapy as a bridge to surgery	Change in patient volume leading to decreased reimbursement in fee-for-service systems	Expected benefit from RT may decrease value from treatment
	Financial Toxicity	Increased financial strain on patients Difficulty Inability to comply with treatment protocols	Uncompensated care	Long-term effects on patients' future income potential and ability to afford future treatment Decreased quality of care with lack of treatment affordability

Key: ESTRO-HERO = European Society of Radiotherapy and Oncology Health Economics in Radiation Oncology, PPE = personal protective equipment, SOP = standard operating procedures, RT = radiation therapy

shifts in the regulatory landscape and the more permanent integration of telehealth into routine practice.[28] Future work will need to evaluate the appropriateness of virtual care in different clinical scenarios and the relative value of this service.

Treatment Planning and Delivery

During the early phase of the pandemic, recommendations to delay or omit radiation treatment to minimize COVID-19 exposure risk contributed to the reduction in revenue for clinical departments.[29,30] For example, omission of radiation therapy with active surveillance was considered a reasonable option for low- and favorable intermediate-risk prostate cancer, whereas delaying radiation through the use of prolonged androgen deprivation therapy of up to 6 to 7 months was acceptable for higher-risk disease.[30,31] For other types of cancer, however, radiation therapy was used as a bridging measure to delay procedures that might be associated with a higher COVID-19 risk or as an alternative treatment option. For example, international experts recommended that short courses of radiation therapy could be used to delay surgery in patients with rectal cancer.[32] In lung cancer, an ESTRO-ASTRO consensus statement recommended the use of stereotactic radiation for patients with operable early stage non-small cell lung cancers in cases where timely access to surgery was unavailable due to surgical capacity issues.[33] This shift in practice is supported by data from the UK that found an increase in the number of radiation therapy courses during the initial months of the pandemic for esophageal, bladder, and rectal cancer, which may reflect the greater use of radiation therapy as an alternative to surgery.[34] These changes to case mix and treatment protocols led to unexpected shifts in department resource allocation, altering departmental costs, reimbursements and human resource needs.[34]

The COVID-19 pandemic also led to the rapid adoption of hypofractionated or accelerated treatment schedules,[3,35] where radiation is delivered at a higher dose over fewer treatments, to minimize patient exposure and maximize treatment unit efficiency.[30] There has been growing interest in using hypofractionation over the last several years to increase machine availability, reduce resource consumption, and improve patient convenience. In the fee-for-service setting, however, where remuneration has been tied to the number of fractions delivered, uptake on hypofractionation had been slow, despite the strong evidence base in several indications.[9,36] In contrast to historical hypofractionation utilization rates, COVID-19 prompted the rapid adoption of hypofractionated schedules, which were endorsed by multiple professional societies. For example, the FAST-Forward trial published in April 2020 found that a 1-week course of adjuvant radiation therapy for early stage breast cancer at a dose of 26 Gy in 5 fractions was noninferior to moderate hypofractionation delivered over 3 weeks in terms of ipsilateral breast tumor relapse and normal tissue effects.[37] This fractionation scheme was widely adopted in international centers following its publication[38] and was established as a standard of care at a U.K. consensus meeting in October 2020.[39] A cost-minimization analysis in the Canadian context found that implementation of FAST-Forward results in a 36% reduction in infrastructure and human resource costs compared with standard fractionation, which translated to an annual savings of over $2 million Canadian dollars (CAD) per year at the provincial level and $174,700 per year at the institutional level.[40] However, these savings require flexibility in equipment and personnel costs, which are sometimes fixed at the departmental level. A transition to hypofractionated schedules was suggested as a safe strategy for several other curative and palliative radiation therapy indications.[30,41]

Post-treatment

Once treatment has been completed, patients require ongoing surveillance for recurrence, and monitoring for radiation-related toxicities. COVID-19 made surveillance for disease recurrence more challenging to access, particularly as health resources were diverted towards management of the pandemic, and follow-up assessments to evaluate for disease recurrence or residual toxicities were increasingly done virtually.[42] The Multinational Association of Supportive Care in Cancer Survivorship Group conducted a qualitative survey of their membership to evaluate how members and their respective institutions have modified cancer survivorship practices and services during COVID-19.[43] One of the priority areas to emerge from this survey was the opportunity for cancer care practitioners to decentralize or delegate care from the specialist setting. These may include alternative models of care such as shared care or nurse or primary care provider-led models, which would allow oncologists to provide a greater focus on acute patients requiring urgent care.[43] The opportunity to implement these new models of care has refocused attention on opportunities for improving value-based care delivery in which high-quality care can be delivered in lower-cost settings.[44]

Economic Impact on Radiation Oncology Support Activities

Numerous supportive activities are essential for any functioning radiation oncology service, including departmental management, implementation of new technology, research, and evidence generation. COVID-19 impacted each of these areas through reduced staffing availability, funding challenges, and new

operating procedures, but also led to a renewed commitment to invest in high-quality real-world data systems and randomized controlled trials to guide practice.

Departmental Management

Radiation oncology departments were required to rapidly adapt their standard operating procedures (SOP) and workflows to ensure the safe provision of treatment during the pandemic. One survey of 68 radiation oncologists across 13 countries found that modifications were made to treatment protocols in 85% of cases.[45] This resulted in unexpected overhead costs related to the development of new SOP documents for patient management, screening and cleaning procedures, treatment procedures, safe work practices, PPE guidelines, rules for staff quarantine and isolation and work-from-home guidelines.[46] The use of telemedicine also impacted the cost of care delivery due to the need for new information systems and online workflows to support virtual encounters,[47] although it led to significant indirect cost savings through reduced travel costs and patient time away from work.[23,48]

Operational costs also increased due to greater personnel needs and training, consumables such as masks and PPE, increased treatment times due to cleaning procedures and potentially slower patient setup while wearing PPE.[2] There were also additional overhead costs for plexiglass and other physical barriers at screening and registration desks.[49] Further, burnout from the COVID pandemic has also been well-documented to affect productivity and the challenges with family support and childcare (eg, high-risk elderly parents, closed schools), and employee sick leave due to COVID-19-related illness or quarantine requirements have all affected departmental staffing and efficiency. In some US jurisdictions, the staffing challenges have led to higher costs related to hazard pay, salary increases, signing bonuses and improved benefits packages.[50]

Implementation of New Technology, Research and Evidence Generation

Evidence generation is essential for making better choices about health care and health care funding. The impact of the pandemic on the field of evidence generation has been mixed. Prior to the pandemic, the lack of real-time and real-world evidence slowed the uptake of new and beneficial advances and has often resulted in ineffective, costly, or even harmful interventions remaining in clinical use.[51] However, COVID-19 has highlighted the importance and need for population databases, resulting in increased investment in this important research area. New consortia to rapidly address cancer-specific research questions were developed, such as the COVID-19 and Cancer Consortium (CCC19), which aims to bridge the knowledge gap in cancer care caused by the COVID-19 pandemic.[52] Several other registries and consortia to support real-world data collection on cancer and COVID have emerged internationally, many of which are spearheaded by professional societies such as the American Society of Clinical Oncology (ASCO), European Society for Medical Oncology COVID-19 Care (ESMOCoCare), and the European Organization for Research and Treatment of Cancer (EORTC) E^2-RADIatE.[53] Such data can contribute to more robust health technology assessment in cancer and improved evaluation of the magnitude of benefit and cost-effectiveness of radiation therapy interventions.

A major challenge in evidence generation during the first year of the pandemic, however, was the dramatic reduction in enrollment in clinical trials in oncology, collection of patient samples for cancer research, and preclinical bench work.[46] The scale-up of clinical trial activity following the initial shutdown, however, provided an opportunity to evaluate which components of clinical trials were necessary to reach the goal of testing the effectiveness of cancer therapy. Such changes have the potential to improve the benefit that patients are receiving from participation and reduce unnecessary visits.[55] Funding opportunities also changed, with a reduction in opportunities for non-COVID research, as research budgets for cancer were reduced to shift funds toward COVID-related research activities. The Association of Medical Research Charities estimated a £252 to 368 million shortfall in research investment in 2020-2021[56] and similar declines in funding availability have been seen globally.[57]

Economic Impact on Activities Beyond Radiation Oncology

Beyond the treatment of the disease itself, many other aspects of care delivery, including surgery, systemic treatment, supportive care, and rehabilitation have all been affected by the pandemic. In England, premature cancer deaths resulting from diagnostic delays from breast, colorectal, esophageal, and lung cancer during the first wave of the pandemic are estimated to amount to a loss of 32,700 quality-adjusted life years and productivity losses of £103.8 million GBP.[58] Further, the economic strain experienced by patients in other aspects of their personal lives during the pandemic has implications for outcomes and compliance with treatment. There is growing literature on the burden of financial toxicity that patients experience, which includes the objective financial burden of cancer treatment as well as subjective financial distress. Loss of income and prolonged unemployment from the

pandemic created a double financial burden for many patients.[59]

Conclusion

The COVID-19 pandemic has led to many changes in radiation therapy delivery, which have impacted the economics of radiation oncology care. While some of these changes, such as the reduction in clinical volume and increased need for PPE, may be temporary during periods of increased COVID-19 infection, others such as the use of virtual care and hypofractionation may lead to more permanent changes. These changes require ongoing evaluation and monitoring and may prompt payers and health systems to consider new and more flexible reimbursement models. A renewed emphasis on evidence generation, which was motivated by the pandemic, may facilitate more robust and timely health technology evaluation of new models of care and new innovation in treatment.

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Formalized Mentorship in Radiation Oncology in the COVID Era: American College of Radiation Oncology Experience

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Abstract

Background: Formal mentorship in radiation oncology can create opportunities and promote career advancement, job satisfaction, and professionalism. Here, we report the results of the American College of Radiation Oncology (ACRO) Mentorship Program 2020-2021.

Methods: The ACRO Mentorship Program is advertised by email and social media, and dyad pairing occurs on a rolling basis every 2 weeks. We encourage participation from private practice, academic practice, and international applicants. A survey to assess program effectiveness was emailed to all participants in February 2021, and the results were analyzed.

Results: Seventy-eight individuals enrolled in the mentorship program: 40 to become a mentor, 50 to become a mentee; 12 individuals were interested in both. The survey response rate was 42.3%, and 66.7% believed that a formal mentorship is more beneficial compared with informal opportunities. The most common methods of mentor-mentee communication were via email (54.5%), video call (51.5%) and phone (45.5%). Survey respondents noted mutual respect, personal connection, shared values, and clear expectations in the mentor-mentee relationship. Participants felt mentors modeled professional and ethical behavior, taught new skills, and advised on career advancement and work-life integration. The majority of respondents (60.6%) desired to continue their mentor-mentee relationship beyond the formally required 1 year.

Conclusion: Formal mentorship programs remain a successful intervention in the COVID era and may be more beneficial compared with informal opportunities.

Keywords: Radiation oncology, mentorship, American College of Radiation Oncology

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Table 1. Baseline Characteristics of Participants

BASELINE CHARACTERISTICS	MENTOR (N = 40)	MENTEE (N = 50)
Position		
Medical student	0	23 (46%)
Junior resident (PGY1-3)	11(27.5%)	15 (30%)
Senior resident (PGY4-5)	8 (20%)	10 (20%)
Academic faculty	16 (40%)	0
Private practice physicians	5 (12.5%)	2 (4%)
Gender		
Male	23 (57.5%)	25 (50%)
Female	15 (37.5%)	24 (48%)
LGBTQI	2 (5%)	1 (2%)
Current location		
Northeast	6 (15%)	18 (36%)
Midwest	16 (40%)	16 (32%)
South/southeast	11 (27.5%)	11 (22%)
West	5 (12.5%)	1 (2%)
International	2 (5%)	4 (8%)

Mentorship is a critical component of medicine and can help with career advancement, job satisfaction, reinforcing ethics, and professionalism.[1-4] Mentorship opportunities range from informal to formal, and participation can be either voluntary or mandatory.[5] Informal mentorship can develop naturally from professional relationships and is frequently built upon mutual interests. Formal mentorship further extends opportunities to mentees who might not be able to secure a mentor within their own institution.[6] Radiation oncology (RO) is a small specialty, and mentorship is important for career advancement.[7] Medical students, specifically, may be at institutions without RO departments, making RO mentorship opportunities difficult to establish. In addition, as discussed by Seldon et al, it is often more difficult for women to find a female RO mentor.[8] By helping to fill these gaps, formal mentorship programs may plan an important role in our field.

The American College of Radiation Oncology (ACRO) has been offering a dyad mentorship opportunity[9] to medical students, residents, and new practitioners since 2015.[10] In this program, mentors and mentees communicate via virtual platforms and can meet in-person at national meetings, such as the ACRO annual meeting. In this paper, we report the results of the ACRO Mentorship Program 2020-2021 and investigate its effectiveness in the era of COVID-19, which poses unique challenges for mentorship programs including physical distancing, financial losses, and competing priorities.[11]

Methods and Materials

The ACRO Mentorship Program starts in June and officially ends in May, spanning the academic year. The program is advertised on the ACRO website, by email, Twitter, personal referrals, and during the ACRO annual meeting. The ACRO Resident Committee sends out flyers to programs and highlights the mentorship program as a benefit of ACRO membership. The only requirement to enroll in this program is to fill out a form on the ACRO website, which collects demographic and geographic information, level of training, and specific personal requests. Pairing occurs on a rolling basis that happens every 2 weeks. Medical students, interns, residents, new practitioners, academic faculty, and private practice physicians can apply. Pairing is based on mentor and mentee requests. In addition, the program receives support from the ACRO resident and new practitioner committees to find appropriate mentors. Reminders are sent to mentor-mentee pairs before national meetings to encourage the mentor-mentee relationship and consideration of an in-person meeting.

A survey to assess program effectiveness was designed and sent to all participants in February 2021. The anonymous survey was modeled after the Society of Women in Radiation Oncology (SWRO) mentorship questionnaire (see survey in **Supplemental Material** available online).[8] Internal review board (IRB)

Table 2. Baseline Characteristics of Participants Who Filled Out the Survey

Role in the Program	
Mentor	14 (42.4%)
Mentee	13 (39.4%)
Both	6 (18.2%)
Position	
Medical student	10 (30.3%)
Junior resident (PGY1-3)	8 (24.2%)
Senior resident (PGY4-5)	7 (21.2%)
Junior faculty (academic)	1 (3.1%)
Junior faculty (private practice)	0
Senior faculty (academic)	3 (9.1%)
Senior faculty (private practice)	4 (12.1%)
Gender	
Female	13 (39.4%)
Male	20 (60.6%)
Current location	
Northeast	6 (18.2%)
Midwest	12 (36.4%)
MidAtlantic	1 (3%)
Southeast	6 (18.2%)
South	3 (9.1%)
West	4 (12.1%)
International	1 (3%)

exemption was obtained from Indiana University. All participants received an email with the Google Form survey link. The baseline characteristics and survey results were analyzed using JMP Pro 15 (SAS Institute Inc.). Chi-squared test was used and a *P*-value less than 0.05 was considered statistically significant.

Results

In the study period (June 2020 to May 2021), 78 individuals enrolled in the mentorship program: 28 to become a mentor, 38 to become a mentee; 12 individuals were interested in both. Therefore, there were 40 mentors and 50 mentees in the program. Baseline characteristics of mentorship program participants are summarized in **Table 1**. The mentor group consisted of radiation oncology residents (47.5%), academic faculty (40%) and private practice physicians (12.5%). Among resident mentors, 58% were junior (postgraduate year, PGY 1-3) and 42% were senior (PGY 4-5) residents. More than half of the mentors were males (57.7%), and 5% self-identified with the LGBTQI+ community. Geographic distribution of mentors was: 40% midwest, 27.5% south/southeast, 15% northeast, 12.5% west coast, and 5% international. Within the mentee group, 50% were residents, followed by medical students (46%) and new practitioners (4%). Half of the mentees were male and 2% associated with the LGBTQI+ community. Geographic distribution was: 32% midwest, 22% south/southeast, 36% northeast, 2% west coast, and 8% international. The distribution of mentors across residency training years was: 60% junior (PGY1-3) and 40% senior (PGY4-5).

There was a 42.3% overall response rate to the survey: 14 mentors, 13 mentees, and 6 both. Therefore, the response rate was 50% (20/40) in the mentor group and 38% (19/50) in the mentee group. **Table 2** summarizes the baseline characteristics of survey respondents. For 72.7% of the participants, this was their first year in the ACRO mentorship program. The survey showed that the most common method of communication between mentors and mentees was email (54.5%), followed by video call (51.5%) and phone (45.5%). Finally, 24.2% had the opportunity to meet in-person despite COVID pandemic restrictions.

Before initiating mentorship, 51.5% had no expectation about the number of interactions. However, 57.6% had at least 2 scheduled interactions since being paired. The pairs also managed to communicate outside scheduled interactions in 72.7% of cases. Either mentors or mentees set up the interactions in 54.5% of pairs, with mentees alone being responsible in 27.3% of pairs.

The survey considered different domains from which the mentor-mentee pairs benefited (**Table 3**). Mentees believed that mentors modeled professional and ethical behavior, taught them a new skill or knowledge, and advised on career advancement and work-life integration. Mentees also thought this relationship helped them promote networking. Mentors also answered the same questions about how they thought the relationship helped their mentees. Mentors believed they had more influence on direct and indirect job/residency placement

Table 3. Mentor and Mentee Thoughts About How the Relationship Helped the Mentee

	MENTEE (N = 19)	MENTOR (N = 20)	*P*-VALUE
Promoted your career through networking			
Not at all	1	0	0.16
A little bit	8	10	
Quite a bit	5	9	
A lot	2	0	
N/A	3	1	
Directly resulted in a job/residency position for mentee			
Not at all	2	7	0.0001*
A little bit	0	6	
Quite a bit	0	3	
A lot	0	0	
N/A	17	4	
Indirectly resulted in a job/residency position for mentee			
Not at all	2	5	0.007*
A little bit	1	7	
Quite a bit	2	3	
A lot	0	1	
N/A	14	4	
Positively impacted mental health/wellness			
Not at all	2	2	0.7
A little bit	4	8	
Quite a bit	5	5	
A lot	4	3	
N/A	4	2	
Advice about career advancement			
Not at all	0	0	0.17
A little bit	3	6	
Quite a bit	6	9	
A lot	8	5	
N/A	2	0	
Advice on navigating departmental and career-related politics			
Not at all	2	3	0.12
A little bit	2	5	
Quite a bit	5	8	
A lot	3	3	
N/A	7	1	
Advice on work-life integration			
Not at all	1	1	0.08
A little bit	5	13	
Quite a bit	5	3	
A lot	4	3	
N/A	4	0	

	MENTEE (N = 19)	MENTOR (N = 20)	*P*-VALUE
Research advisor or collaborator			
Not at all	9	9	0.001*
A little bit	1	8	
Quite a bit	0	2	
A lot	0	0	
N/A	9	1	
Advocated for you			
Not at all	3	4	0.001*
A little bit	2	8	
Quite a bit	4	4	
A lot	1	3	
N/A	9	1	
Advice on leadership			
Not at all	3	1	0.001*
A little bit	2	15	
Quite a bit	5	3	
A lot	4	1	
N/A	5	0	
Modeled professional and ethical behavior			
Not at all	2	2	0.004*
A little bit	0	8	
Quite a bit	5	6	
A lot	10	3	
N/A	2	1	
Taught you knowledge or skill			
Not at all	1	1	0.7
A little bit	7	11	
Quite a bit	5	5	
A lot	3	2	
N/A	3	1	
Helped you serve as an oral discussant, write an editorial			
Not at all	6	8	0.0005*
A little bit	0	8	
Quite a bit	1	2	
A lot	1	0	
N/A	11	2	

**Statistically significant*

($P = 0.0001$ and $P = 0.007$, respectively), research advice/collaboration ($P = 0.001$), advocating for mentee ($P = 0.001$), leadership advice ($P = 0.001$), modeling professional/ethical behavior ($P = 0.004$), and writing an editorial/serving as a discussant ($P = 0.0005$), compared with what mentees believed.

Mentors reported experiencing mutual respect (95.2%), a personal connection (66.7%), clear expectations (42.9%), and shared values (38.1%). Mentees similarly reported mutual respect (94.7%), shared values (73.7%), a personal connection (57.9%) and clear expectations (47.7%). A small minority of mentors reported lack of experience (9.5%) and lack of commitment (5.3%) in mentees, but mentees

did not have the same concerns about the mentors.

Among the survey respondents, all participants had expressed having additional mentorship relationships beyond the ACRO program. Most (66.7%) believed that a formal mentorship is more beneficial compared with informal opportunities, while 30% felt both mentorship types are equally beneficial. Finally, 60.6% of participants were very satisfied with their pairing and would like to continue their mentorship relationship beyond the formal 1-year duration of the program.

Discussion

Our study showed that a formal mentorship program in the COVID era continues to be a successful paradigm, with participants reporting the strategy to be more beneficial compared with informal opportunities. The benefits of a formal mentorship program and participants' experience include mutual respect, personal connection, a shared value set, and clear expectations. This study also showed that mentor and mentee interpretation of relationship and benefit aspects can vary. In certain aspects, such as advocacy, job/residency placement and writing an editorial/serving as the discussant, the mentee might not be aware of the role of mentor in these domains. However, in other aspects, such as leadership and research advice, mentors may need to communicate more clearly with mentees.

The ACRO Mentorship Program has mentors currently in private practice (12.5% of the mentor group). As 60% of radiation oncologists work in private practice,[12] it is important to find ways to encourage more involvement of this group in mentorship programs. In addition, this year we were able to expand the program to provide mentorship opportunities internationally, in both mentor (5%) and mentee groups (8%). There were students and graduates enrolled in our program who were interested in pursuing training in the US and were seeking mentors with a similar background. Finally, we received a few requests (3.8% in the overall mentor/mentee pool) from the LGBTQI+ community and were able to provide better support by finding them a mentor/mentee from the LGBTQI+ community. Based on our experience from last year, we have updated our registration form to be more inclusive with respect to the background of our participants to fulfill their requests with the goal of a higher satisfaction rate and a more meaningful relationship.

In a recent publication by Marsiglio et al, 13 papers on mentorship in radiation oncology were reviewed.[9] Similar to the ACRO program, the dyad mentorship was found to be the most reported type of mentorship. This review also demonstrated that participants were more satisfied with formal mentorship compared with informal mentorship, as found in our study. Additionally, achieving career goals and work-life balance were among the benefits of the mentorship program participation, which is similar to our findings. However, the participants in the ACRO Mentorship program also felt that the relationship helped them model professional and ethical behavior. Our study showed a higher satisfaction rate, with 60.6% of participants wishing to continue their relationship, compared with 35.7% in the review.[9] This might be due to the larger and heterogenous pool of participants in the Marsiglio et al study. In addition, participants can share their specific requests and interests on the ACRO Mentorship Program registration forms, and ACRO committee members work to honor these requests when possible.

With advancements in technology as well as the ongoing COVID pandemic, virtual platforms are now used as one of the main methods of communication in mentorship programs.[13] In our ACRO mentorship program, 51.5% used video calls to communicate. As discussed by Seldon et al, SWRO has also used digital mentorship.[8] The virtual platform has enabled the ACRO Mentorship Program to engage participants from different states and countries and is likely an important contributor to the continued success of the mentorship program in the COVID era. The American Society of Radiation Oncology (ASTRO) mentorship match program reported results at the 2017 ASTRO annual meeting. There was no virtual option for this program; 64% of residents and 73% of attendings preferred in-person meetings, and only 21% of residents expressed interest in a mentorship program utilizing social media.[10] Participants' preferences have changed over time, which may be related to increased comfort with virtual platforms in the COVID era. Social media may also have more application in current mentorship models. With more programs turning toward virtual platforms and social media, it is possible to connect mentors and mentees from different institutions and allow them to develop a mentorship relationship.

This study has its own limitations. Longer follow-up will be beneficial to better assess the long-term benefits of the mentorship program. We only assessed the short-term benefits of a formal mentorship program. Based on Kashiwagi et al systemic review results,[14] future programs can also investigate providing goal setting and career planning worksheets to better guide the relationship since our study showed that less than half of the participants had clear expectations about their relationship. Another limitation of this study is the low rates of participation from private practice (12.5%). In addition, we had

a modest response rate with 42.3% of participants sharing their experience. Finally, we did not collect comprehensive demographic data regarding race/ethnicity and were unable to meaningfully assess diversity and our program's ability to assist underrepresented minorities.

Conclusion

The ACRO Mentorship Program provided formal RO mentorship opportunities and resulted in high rates of participant satisfaction despite challenges of the COVID era. This program will continue to engage participants from all scopes of practice (academia and private practice), diverse backgrounds, and underrepresented RO groups such as women and will also continue to use virtual platforms in addition to in-person meetings to promote the mentor-mentee relationship.

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ASTRO 2021 Exhibits Highlight Personalized Adaptive Therapy, Workflow Efficiency

Mary Beth Massat

Over the last decade, advances in radiation treatment planning and delivery have contributed to longer survival rates and more people living with cancer. With that comes a heightened focus on personalizing treatment by adapting therapy to the patient and reducing side effects with improved lesion detectability and targeting methods, thereby improving quality of life. Manufacturers at this year's American Society for Radiation Oncology (ASTRO) showcased new or enhanced technologies that impact workflow and the processes for treating patients with these core benefits in mind.

At **ViewRay**, new features in treatment planning and delivery were geared to either enable more personalized treatments for a particular patient or streamline the re-optimization planning to allow for more patient treatments.

The goal, says Mike Saracen, vice president of marketing, is to significantly reduce the workflow process, to enhance on-table adaptive planning, and expand the clinical utility of MRIdian, the company's MR-guided radiation therapy (MRgRT) system. New one-click tools for auto-contouring and auto image registration streamline workflow. Users can now utilize gating tools and perform 2D real-time dose distribution in the sagittal, coronal and axial planes. Additionally, a new brain treatment package and brain coil allow for 0.75-mm, thin-slice 3D acquisitions. With specialized glasses, patients also can now see their treatment plan, further empowering them to participate in their health care.

Results of 148 inoperable pancreatic cancer patients treated with MRIdian SMART (MR-guided stereotactic adaptive radiation therapy) were presented at the conference, showing longer median survival of 26 months compared with 12 to 15 months for patients who received standard radiation therapy and chemotherapy.

"We are thrilled to see such an improvement, with long-term survival more than doubling when MRIdian SMART was used to treat this population of patients," says Michael Chuong, MD, medical director of radiation oncology at Miami Cancer Institute, part of Baptist Health South Florida. "In fact, some patients were still alive several years later with excellent quality of life. These results are a significant improvement over historical outcomes from standard computed tomography (CT)-guided radiation therapy."

At **Reflexion**, Chief Medical Officer Shervin "Sean" Shirvani, MD, MPH, said the RefleXion X1 has treated approximately 30 patients at 3 installed sites. The system combines positron emission tomography (PET) and 16-slice fan-beam kVCT imaging capabilities with a linear accelerator, enabling head-to-toe motion management and the ability to see and treat tumors using disease-specific tracers. This approach may allow for multiple tumors to be treated in 1 session as well as utilize the

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Figure 1. The Multimodality RT Simulation Workspace by Royal Philips provides a vendor-agnostic single space for simulation, multimodality image fusion and contouring.

biology of the cancer to guide radiation therapy, a process called biology-guided radiation therapy (BgRT), which is currently limited to investigational use in the US.

Treating oligometastatic disease is one area where Dr. Shirvani sees great potential for the technology, with the ability of PET to track the radiotracer signal and detect subtle lesions. The company has partnered with **Telix Pharmaceuticals** and **Lantheus** to explore the use of novel PET tracers beyond the use of fluorodeoxyglucose (FDG).

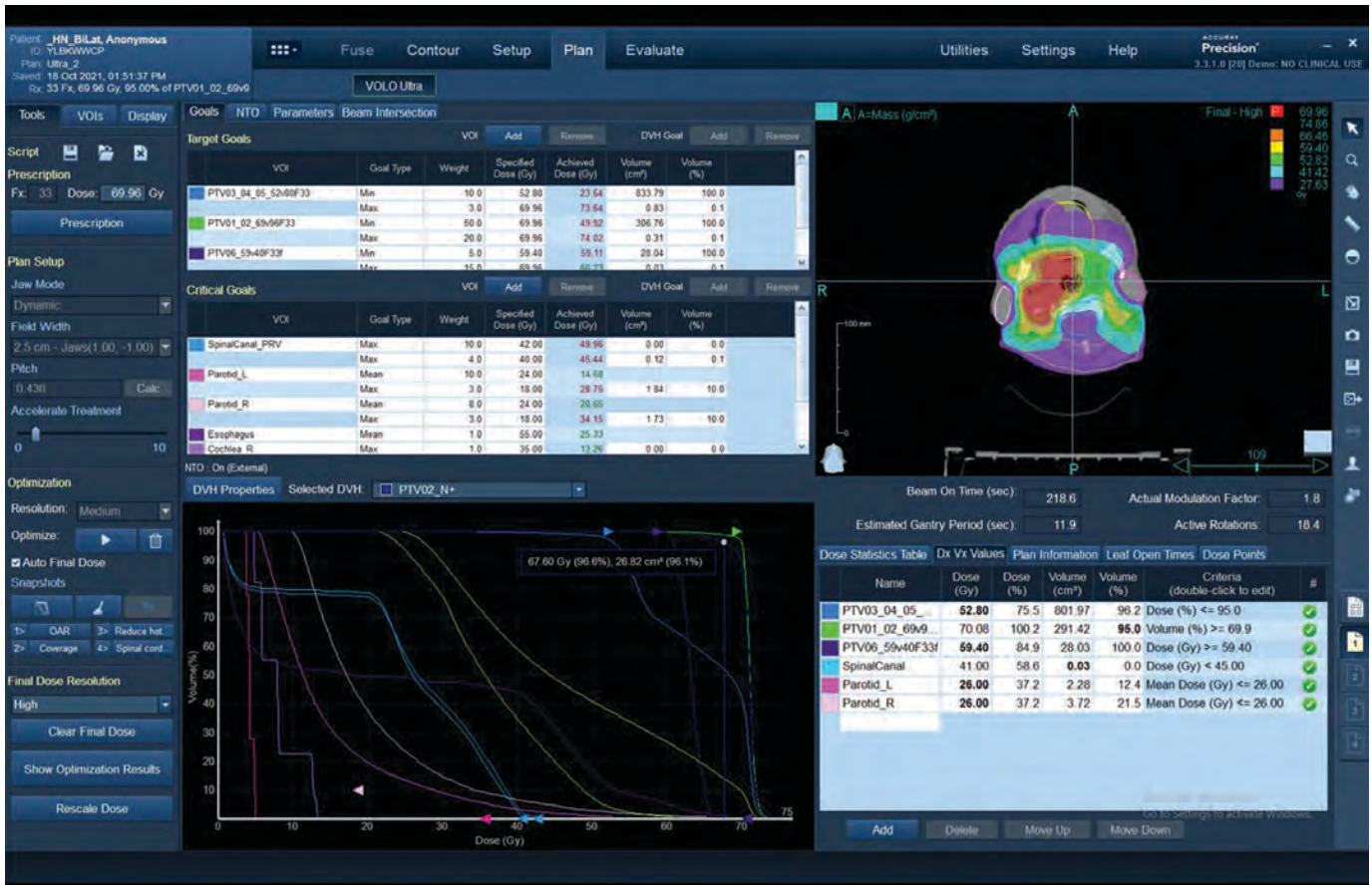
"With BgRT and PET imaging during treatment, our future goal is to decrease toxicity and open the door for more treatments in patients with oligometastatic or metastatic disease and not exhaust their (lifetime) radiation dose limits," says Dr. Shirvani.

At the **Siemens Healthineers** and **Varian** booths, the companies connected dots with their combined vision and fight against cancer to accelerate the path from diagnosis to survivorship. The companies are working together to "close the gap between resources available to patients around the world," said Tracey Fisher, senior director, Americas/global field marketing. "Where you live should not determine how and where you are treated."

Varian's Ethos therapy Adaptive Intelligence solution is designed to increase quality of life by adopting a patient-centric, personalized care approach. With approximately 40 systems in clinical use, Varian showcased the broad array of disease sites Ethos has targeted and how it can deliver adaptive planning in a standard 15-minute treatment slot, representing a "sea change in technology," says Stephen Thompson, MS, DABR, senior product manager. Thompson adds that data from the Adaptive Intelligence Consortium shows that 81.5% of physicians using Ethos chose the daily adaptive plan based on tumor and anatomical changes.

The company also highlighted IDENTIFY, a new surface-guided positioning solution for patient verification and precise set-up to enhance safety. It uses a camera-projected light to increase accuracy and reproducibility across treatment fractions to provide the clinician with more confidence when utilizing hypofractionated plans and help reduce patient side effects. A biometric scanner verifies the patient, and RFID technology helps align the patient to submillimeter accuracy. Also featured was Noona, a patient engagement platform that interfaces with Aria or Epic to serve as a communication tool between the care team and patient.

Figure 2. VOLO Ultra is a new feature of the Accuray Precision Treatment Planning System designed to accelerate Radixact and TomoTherapy treatments and optimize plan quality.



At Siemens, the company showcased its synthetic CT solution for MR simulation, including the use of 4D MRI, as well as artificial intelligence (AI)-based auto contouring tools now available in the cloud in addition to being on the CT console or workstation. The cloud-based tools may increase availability to users who seek to provide a more personalized patient experience as well as shorten time from diagnosis to treatment, says Christoph Bauer, director of global clinical marketing for cancer therapy.

Elekta Unity was a highlight at the **Elekta** booth, buoyed by several award-winning abstracts demonstrating MRgRT benefits and the power of the system to generate information to improve therapy precision and optimize online adaptive workflow. The abstracts include two that received Basic/Translational Science Abstract Awards and were selected from nearly 2,000 submissions; one also received an ASTRO Recognition Award. "Elekta Unity is at its core an information-generating linear accelerator, one that gives clinicians information about anatomy, dose and biology," says John Christodouleas, MD, senior vice president of medical affairs and clinical research. "This information can be used to improve the precision of radiotherapy and optimize the online adaptive workflow."

Elekta Studio, a fully connected image-guided brachytherapy suite with ImagingRing enables 2D cone-beam and fluoroscopic imaging that moves around the patient up to 360 degrees. Clinicians can image patients in the treatment position in the 120-cm bore of ImagingRing, export the images to the planning software and afterloader, and begin treatment – in 1 room and without moving the patient.

On Elekta Harmony, FastTrack can halve patient set-up time with the addition of controls on the patient treatment table by integrating iVue on the panel and using facial recognition software as part of the patient verification step. Quality assurance is also now fully integrated into the system, allowing the physicist to access all tests online and confirm

completion. This feature is particularly useful for centers without a physicist on-site at all times. With FastTrack, the Elekta Harmony has enabled users to conduct a standard 15-minute treatment in as little as 9 minutes.

FUJIFILM Healthcare Americas announced the grand opening of UroPartners' oncology center in Gurnee, Illinois, featuring FujiFilm's Persona CT for oncology simulation and general radiography imaging. With an 85-cm bore, which matches the arc of a linear accelerator, Persona CT delivers 64/128 slice imaging for submillimeter, high-resolution images. The system also has an extended field-of-view (FOV) and 4D gating with a grid overlay, says Rick Banner, senior director of marketing.

Also on display in the FujiFilm booth was its Virtual Hospital, highlighting the company's portfolio, including the recent Hitachi Healthcare Americas acquisition. "With 80 years of experience in image processing, we'll [continue to] leverage our experience in image processing and AI to expand in other areas," says Banner.

GE Healthcare showcased its oncology technologies that provide clinicians with images and information needed for precise treatment tailoring. In particular, the company will integrate Spectronic Medical AB's AI-based software for generating synthetic CT images from high-quality MR images and collaborate with Vysioneer to include its VBrain solution for auto-contouring of brain metastases, meningioma and acoustic neuroma.

Another key collaboration is the integration of Mirada Medical's RTx into GE's AW Workstation and AW Server to enhance visualization and diagnostic capabilities. RTx is a comprehensive image registration and visualization solution with multimodality contouring, adaptive planning and 4D image support.

The company also introduced the Discovery RT Gen 3 wide-bore CT simulator, providing submillimeter images free of motion and metal artifacts. The system also allows for simulation across an 80-cm field of view (FOV) reconstruction with MaxFOV 2, GE's next-generation extended FOV technology for radiation therapy planning. "The unique needs of radiation oncology make it important to have image data across the entire bore of the CT simulator. Patients are often positioned off-center to accommodate positioning accessories, and dose calculations require data from the entire physical anatomy," says Anna Flahaven, solutions marketing manager, molecular imaging and computed tomography (MICT).

Royal Philips announced new innovations to its Multimodality RT Simulation Workspace (**Figure 1**). Compatible with MR, PET/CT and CT, the solution integrates with picture archiving and communication systems (PACS) and/or imaging devices to provide simulation, multimodality image fusion and contouring in a vendor-agnostic workflow. Common tasks such as normalization, local correlation and cross correlation are automated for MR and CT images. The company also highlighted its integration of MIM Software's Contour ProtégéAI next-generation, deep-learning segmentation solution on Philips' Big Bore RT platform. The recently released Spectral CT 7500 enables patient scanning in the treatment position and provides proton-stopping calculations, such as electron density and effective atomic number.

The company's MR simulation software is tightly integrated with Elekta Unity, including the same tabletop and sequences. The software also includes synthetic CT with pixel-by-pixel Hounsfield units (HU), eliminating the need to confirm HU with an additional CT scan. In addition, the company's new Compressed SENSE accelerates MR image acquisition and reduces the MR simulation acquisition by more than 50%.

Also highlighted was the company's Oncology Pathways for "reducing unwarranted variations in care and providing the same treatment recommendations regardless of who the doctor is," says Louis Culot, general manager, genomics and oncology informatics at Philips. The solution analyzes each plan based on efficiency, cost and toxicity; streamlines workflow with more multidisciplinary tools; assigns tasks for remote staff; and integrates with electronic medical records, PACS, laboratory information systems and pathology information systems. It can also help enhance efficiency in tumor board meetings and help obtain clinical trial consents by auto populating updates to these systems and matching therapies available in the institution to the patient care pathway.

At **Blue Earth**, the company shared the results of its poster lunch symposium presented by Ashesh Jani, MD, FASTRO, the James C. Kennedy Professor in Prostate Cancer at Winship Cancer Institute of Emory University. Dr Jani discussed the first randomized trial of PET using flucliclovine (^{18}F) over conventional imaging alone to

guide radiation therapy decisions and treatment planning. The results demonstrated a significant improvement in failure rates at 3 years. Equally important is that incorporating ^{18}F-PET changed the treatment planning and showed how it impacted the outcome, because the clinician could see the disease, treat more of it, and avoid overtreating it, said Dr. Jani.

Among technology debuts, **Accuray** unveiled VOLO Ultra (**Figure 2**) to help accelerate Radixact and TomoTherapy treatments with an optimizer that includes a fast gradient-based algorithm that auto selects planning parameters for any case. "Even a novice who hasn't planned on this system can generate a high-quality plan efficiently," says Corey Lawson, vice president of product strategy. He adds that optimization time is reduced by 90% and many treatment times become 30% to 60% faster.

On the Radixact system, the new ClearRT helical fan-beam kVCT delivers diagnostic-like quality images thanks to its slip-ring platform. A large FOV – 50-cm diameter and 135-cm scan length – also helps reduce scanning time. When the system is used with Synchrony motion tracking and correction, clinicians can better view the anatomy and track and move the beam to target the lesion for more precise adaptive therapy, Lawson says.

In partnership with **Brainlab**, Accuray is developing a works-in-progress brain package that brings Brainlab's Elements – software that includes interactive and automatic segmentation applications for planning image-guided surgery – to CyberKnife. Accuray will also interface with Brainlab's Quentry Cloud Service so CyberKnife users can participate in the Stereotactic Radiosurgery (SRS) Patient Registry and share data with other institutions globally.

Radiation Recall After the COVID-19 Vaccine: Two Cases and a Review of the Literature

Jason Liu, MD;[1] Jeffrey Wong, MD, PhD;[1] Caitlin Gomez, MD[2]

Radiation recall is a localized inflammatory reaction occurring in a previously irradiated site months to years after discontinuing ionizing radiation exposure.[1] It is frequently associated with chemotherapy agents, especially anthracyclines. To the best of our knowledge, this report is the first description of radiation recall postmastectomy dermatitis and radiation recall proctitis in 2 patients after the vaccine for COVID-19. Our case series adds to the limited existing literature regarding the potential effects of the vaccine that providers should be aware of when counseling patients.

Case Summary

Case 1

Patient 1 is a 43-year-old woman who initially self-palpated a left breast lump in 2019. She underwent a diagnostic mammogram and ultrasound of her left breast, which showed 2 irregular masses, 1 at the 1 o'clock position 10 cm from the nipple measuring up to 5.8 cm, and 1 at the 2 o'clock position 5 cm from the nipple measuring up to 1.7 cm. She was also found to have abnormal lymph nodes in the left axilla. Core-needle biopsy of her 2 left breast masses and her left axillary lymph node showed invasive ductal carcinoma, grade 3, ER-, PR+, Her2+. Genetic testing was positive for BRCA1 mutation. Metastatic work-up including a computed tomography (CT) scan, bone scan, and MRI of the brain was negative. Final stage was cT3 N1 M0.

Patient 1 was started on neoadjuvant docetaxel, carboplatin, Herceptin, and Perjeta (TCHP) for 6 cycles followed by bilateral nipple-sparing mastectomy with left-sided axillary lymph node dissection completed in June 2020. There was minimal residual breast tissue, and the patient had tissue expanders placed at the time of mastectomy for reconstruction. Surgical pathology showed pathologic complete response in the left breast and axilla, ypT0 N0. The patient then started on maintenance Herceptin for 1 year. She also underwent postmastectomy radiation 50 Gy in 25 fractions to the left chest wall and regional lymph nodes (axillary level I-III, supraclavicular [SCV], and internal mammary nodes [IMN]) completed in October 2020. The patient experienced some mild grade 1 dermatitis at the end of treatment, but this fully resolved 1 to 2 months after treatment, with minimal residual hyperpigmentation in the left axilla.

Patient 1 received her first Moderna vaccine in March 2021 and her second on April 2, 2021. On April 12, 2021, the patient developed low-grade fevers and malaise with left breast erythema, edema, and tenderness in the field of prior radiation (**Figure 1**). This was initially believed to be related to an infection, so the patient was started on Bactrim, with subsequent improvement in erythema and edema. However, skin reaction continued to worsen with development of dry and moist desquamation. She was managed with nitroglycerin cream and Neosporin and was later diagnosed with radiation recall dermatitis. She was also incidentally diagnosed with hypothyroidism by her primary care physician around this time, with TSH of 54, and was started on levothyroxine. After 6 months, the patient's left breast is nearly fully healed with no more wet desquamation and she will be able to proceed with planned implant exchange surgery. The only persistent clinical finding is some residual hyperpigmented skin, with mild capsular contracture around the tissue expander.

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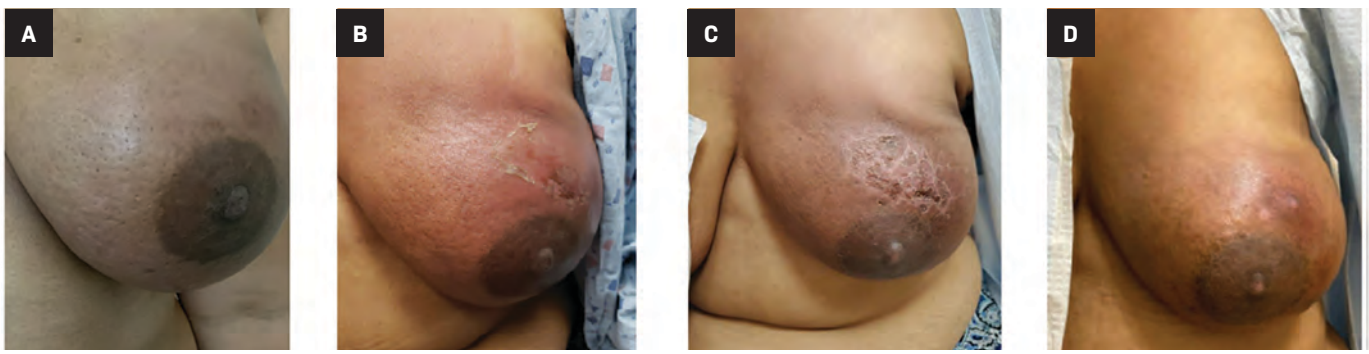
Figure 1. Radiation recall dermatitis in patient 1 at 4 different time points: 17 days after the Moderna vaccine (A), 33 days after the Moderna vaccine (B), 41 days after the Moderna vaccine (C), and 4 months after the Moderna vaccine (D).



Case 2

Patient 2 is a 69-year-old man who was initially found to have an elevated PSA of 5.1 in 2018. Digital rectal examination showed no palpable masses or nodules (T1c disease). MRI of the prostate showed focal findings suspicious for neoplasm in the left posterolateral peripheral apex with capsular margin intact; overall suspicion was PI-RADS 4/5. Subsequent biopsy showed Gleason 3+4 disease in 3/12 cores. Patient 2 then underwent prostatectomy in October 2018, with surgical pathology showing Gleason 4+3 disease, confined to the prostate without extracapsular or seminal vesicle invasion (pT2), and negative margins. PSA decreased to 0.2 in 2019, but never became undetectable, and later rose to 0.3 in 2020, which was concerning for residual disease. The patient then received 45 Gy in 25 fractions to the pelvic lymph nodes with a sequential boost to 70.2 Gy in 39 fractions to the prostate bed, completed in August 2020. He received concurrent Lupron for 6 months. Patient 2 experienced some mild grade 1 urinary frequency and urgency at the end of treatment, but this fully resolved 2 to 3 months after treatment.

Patient 2 received his first Pfizer vaccine on January 19, 2021, and his second on February 9, 2021. On February 27, 2021, the patient contacted his primary care office reporting worsening rectal bleeding. He then developed severe rectal pain. This prompted a colonoscopy in March, which showed ulcerated friable rectal mucosa in the distal 10 cm of the rectum. Biopsy was consistent with radiation colitis, no dysplasia or malignancy. The patient was treated with Anusol suppositories and Proctofoam. Over the next several months, his rectal ulcer and rectal pain improved and the rectal bleeding resolved. It is unlikely that radiation dose contributed to his proctitis given his rectum V65 was only 18%, much lower than the V65 < 35% acceptable limit.

Discussion

Radiation recall is believed to be a local hypersensitivity reaction triggered by the upregulation of inflammatory cytokines that were already increased in the area of irradiation.[1] Reactions typically appear within days to weeks after exposure to the precipitating agent and can vary in severity. The treatment for radiation recall typically involves stopping the precipitating agent and administering steroidal or nonsteroidal anti-inflammatory medications until symptoms resolve.

Currently, the incidence of radiation recall after COVID-19 vaccination is unknown, and only 4 published reports have documented such reactions.[2-5] A summary of these case reports is in **Table 1**. Most cases of radiation recall caused by the COVID-19 vaccine are grade 1 to 2 and have mostly occurred in the skin, although there is 1 published case report of a recall pneumonitis occurring in lung.

Radiation recall typically occurred around 5 to 7 days after vaccination, although 2 cases show that it sometimes presents within hours, as described by Stewart et al and Steber et al.[2,5] Most patients had a history of prior radiation within 1 year of receiving the COVID-19 vaccine. However, 1 patient experienced radiation recall dermatitis 2 years and 3 months after completion of radiation.[4] This was confirmed by biopsy, which showed edema, lymphocyte exocytosis, and dermal collagenization and fibrosis, all consistent with radiation recall dermatitis. It is surprising to see radiation recall phenomenon occur after such a long interval from the time of completion, and more evidence is needed before generalizing. Our 2 patients fit the presentation described in previous case reports.

Initially, it was unclear if patient 1's newly diagnosed hypothyroidism was related to the postmastectomy radiation or the Moderna vaccine. Hypothyroidism is a known late side effect of curative radiation to the

Table 1. Documented Cases of Radiation Recall Dermatitis After the COVID-19 Vaccine

	PATIENT	RADIATION DETAILS	VACCINE TYPE	RADIATION TO VACCINE INTERVAL	VACCINE TO RECALL INTERVAL	REACTION
Present case 1	43 F with left breast cancer	50 Gy in 25 fractions to the left chest wall and lymph nodes	Moderna	6 months	10 days	Grade 2 dermatitis
Present case 2	69 M with recurrent prostate cancer	45 Gy in 25 fractions to the pelvis with sequential boost to 70.2 Gy to the prostate bed	Pfizer	6 months	2 weeks	Grade 2 proctitis
Steber[2]	66 M with metastatic lung cancer	45 Gy in 15 fractions to the right hilum and mediastinum	Moderna	6 months	Hours	Grade 2 pneumonitis
Soyfer[3]	68 M with metastatic sarcoma	50 Gy in 25 fractions to the left posterior chest wall	Pfizer	6 months	1 week	Grade 2 dermatitis
	64 M with metastatic sarcoma	39 Gy in 13 fractions to the right anterior chest wall	Pfizer	1 month	1 week	Grade 1 dermatitis
Afacan[4]	60 F with metastatic melanoma	30 Gy in 10 fractions to 2 lesions on the right medial leg	Sinovac	2 years and 3 months	1 week	Grade 1 dermatitis
Stewart[5]	50 F with right parotid gland cancer	66 Gy in 33 fractions to the right head and neck	AstraZeneca	6 months	Hours	Grade 1 dermatitis

Key: M = male; F = female

neck region in patients with head and neck cancer and lymphomas, but it is not commonly associated with patients who receive breast irradiation. The incidence of hypothyroidism caused after breast irradiation was characterized by Choi et al.[6] It was found that the rate of hypothyroidism at 3 years was 0.8% in patients receiving whole-breast radiation (WBRT) alone and 2.2% in patients receiving regional nodal irradiation, including the SCV (RNI-SCV). The mean thyroid dose was 2 Gy in patients receiving WBRT alone and 8 Gy in patients receiving RNI-SCV. Upon review of patient 1, her mean thyroid dose was around 20 Gy, which likely contributed to her hypothyroidism. This suggests that breast irradiation covering the SCV has a mild to moderate risk of causing hypothyroidism, and providers should consider setting dose constraints to the thyroid gland and counseling patients of this risk. Regarding the risk of hypothyroidism after the COVID-19 vaccine, the incidence is unknown, but most case reports document subacute thyroiditis and not immediate hypothyroidism.[7-10] The classic presentation of subacute thyroiditis involves neck pain with initial hyperthyroidism followed by a transient period of hypothyroidism. Patient 1 did not present with neck pain or initial hyperthyroidism, leading us to suspect that the radiation was the causal agent, possibly exacerbated by the patient's radiation recall dermatitis.

Conclusion

This case report highlights 2 interesting cases of radiation recall, 1 of a patient with prior breast irradiation, and the other with prior pelvic irradiation who developed radiation recall dermatitis and radiation recall proctitis, respectively, within 1 to 2 weeks of receiving the second dose of the COVID-19 vaccine. To the best of our knowledge, this case series is the first description of radiation recall post-mastectomy dermatitis and radiation recall proctitis after the COVID-19 vaccine. Both patients had tolerated their course of radiation well, with mild grade 1 acute toxicities, but had a much more significant grade 2 reaction shortly following COVID-19

vaccine administration. It appears that the radiation recall reactions present in many locations of the body, such as skin, lung, and rectum based on published reports. Given the relative novelty of the COVID-19 vaccine, it is important to highlight these 2 cases to better inform providers about the possible effects of the vaccine and help them counsel patients accordingly, especially if the booster vaccine becomes widely available. However, given the rarity of this phenomenon, COVID-19 vaccination should still be highly encouraged for all patients.

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Delayed Radiation-Therapy-Induced Cerebral Demyelination

Karlo Toljan, MD;[1]* Varun R. Kshettry, MD;[2]* Samuel T. Chao, MD[3]*

Case Summary

A 41-year-old man with no significant medical history presented to the emergency department with new persistent headache. The examination was notable for acromegalic features and right homonymous superior quadrantanopia. A brain MRI scan and laboratory findings were suggestive of growth hormone-secreting pituitary macroadenoma. A 2-stage neurosurgical approach was completed without periprocedural complications. The final diagnosis was consistent with a prolactin and growth hormone-secreting pituitary macroadenoma (Ki67 labeling index 3%). Due to invasive adenoma with residual disease, intensity-modulated radiation therapy was started 4 months after the second surgery, following an informed discussion with the patient (total dose of 5040 cGy in 28 fractions with good tolerance). Three months later, the patient developed vertical diplopia, decreased sensation in the left lower face, slurred speech, tongue numbness, and bilateral upper extremity ataxia. The patient refused hospitalization, but subsequently developed left-sided hemiparesis and was admitted. An updated examination showed dysarthria, binocular horizontal nystagmus in right lateral gaze, decreased hearing on the left, left uvular deviation, decreased elevation of the palate on the right, left tongue deviation, diffuse mild left arm weakness, and left arm ataxia. No vessel abnormalities were noted on head and neck computed tomography (CT) angiography, but a brain MRI scan was showing interval new multifocal lesions. A lumbar puncture was performed, and analyses showed pleocytosis (13 leukocytes per µL), predominantly mature lymphocytes on cytology, and mild protein elevation (50 mg /dL). Oligoclonal bands were not detected, and the IgG index value was 0.64 (0.00-0.61 as normal range). Additional tests including antinuclear antibody; extractable nuclear antigen antibodies panel; c- and p-antineutrophil cytoplasmic antibodies; complement components 3 and 4; C-reactive protein; hepatitis viral panel; blood cultures; spinal fluid bacterial, parasite, viral, and fungal analyses; human immunodeficiency virus panel; and toxoplasma antibodies were performed, but all were unrevealing of abnormalities. A contrasted chest, abdomen, and pelvis CT scan did not show concerning lesions. Ultimately, a stereotactic brain biopsy of right cerebellar hemispheric lesions was performed. Findings were suggestive of a noninfectious inflammatory process compatible with acute demyelination. Notably, family history was unremarkable for autoimmune or demyelinating diseases. Pulse intravenous methylprednisolone (1g/day) was given for 3 consecutive days, followed by oral dexamethasone (4 mg twice daily).

Imaging Findings

Preoperative (**Figure 1A**) and postoperative (**Figure 1B**) MRI brain scans demonstrate debulking of tumor from surgery, yet with residual disease. Radiation treatment was pursued following surgery (**Figures 1C and 1D**). Three months after completion of radiation treatment, and in the setting of new neurological deficits, a brain MRI scan showed multiple new cerebellar and brainstem contrast-enhancing

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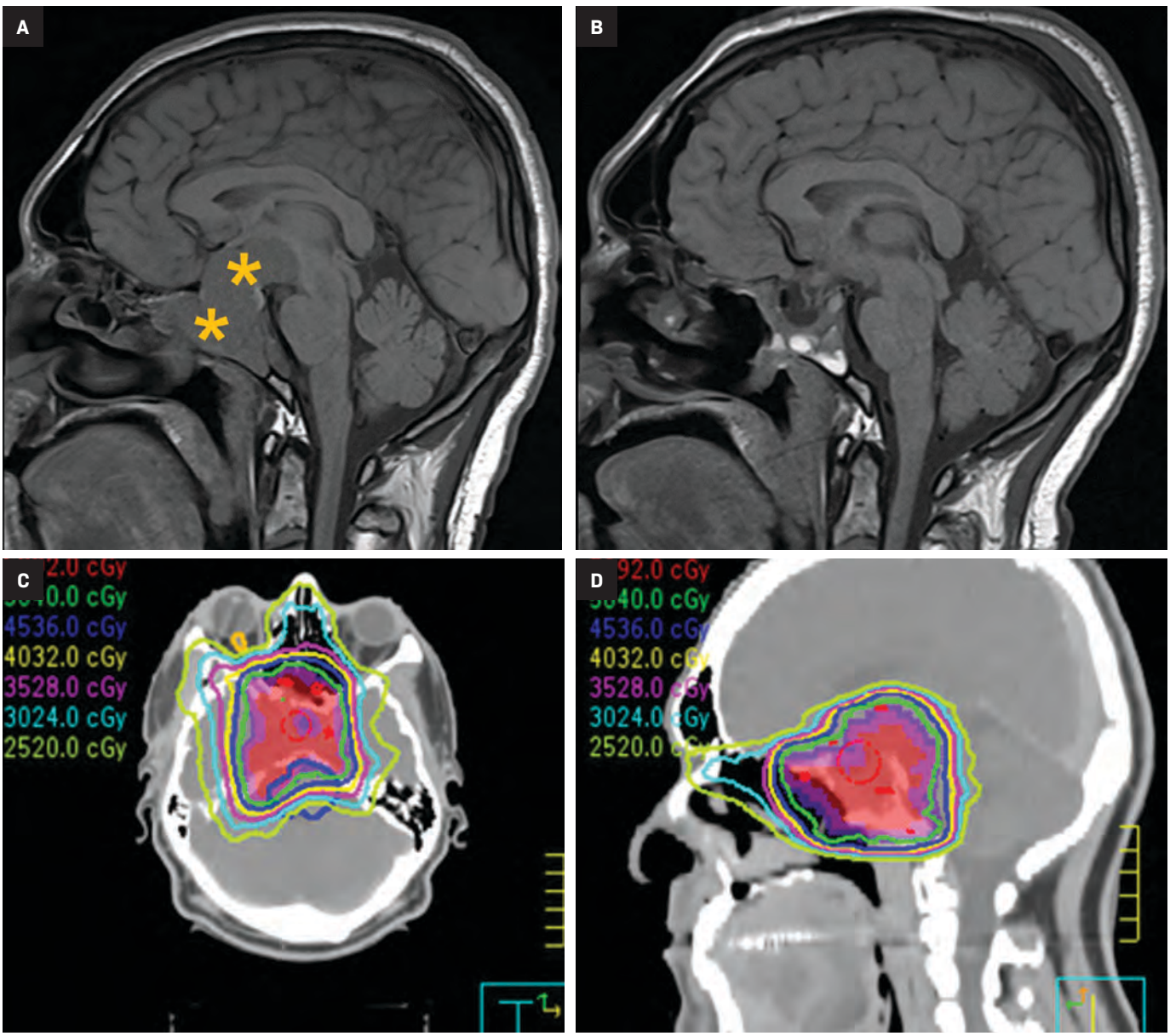
Figure 1. A noncontrasted sagittal T1 MRI sequence scan demonstrating a sellar and suprasellar mass with extension into the right cavernous sinus and posterior fossa (asterisks) (A). Sagittal T1 MRI sequence following surgical treatment (B). Radiation plan scheme that was used to guide radiation therapy (C, D).



and T2/FLAIR-hyperintense lesions (**Figure 2A-D**). Brain biopsy revealed perivascular parenchymal macrophage and lymphocyte infiltration, with decreased myelin staining and some preservation of neurofilament staining, but without granulomas or infectious stigmata (**Figure 3A-D**). Follow-up imaging, 11 months after diagnostic biopsy, showed resolved features of demyelination, with some residual changes (**Figure 4A-D**).

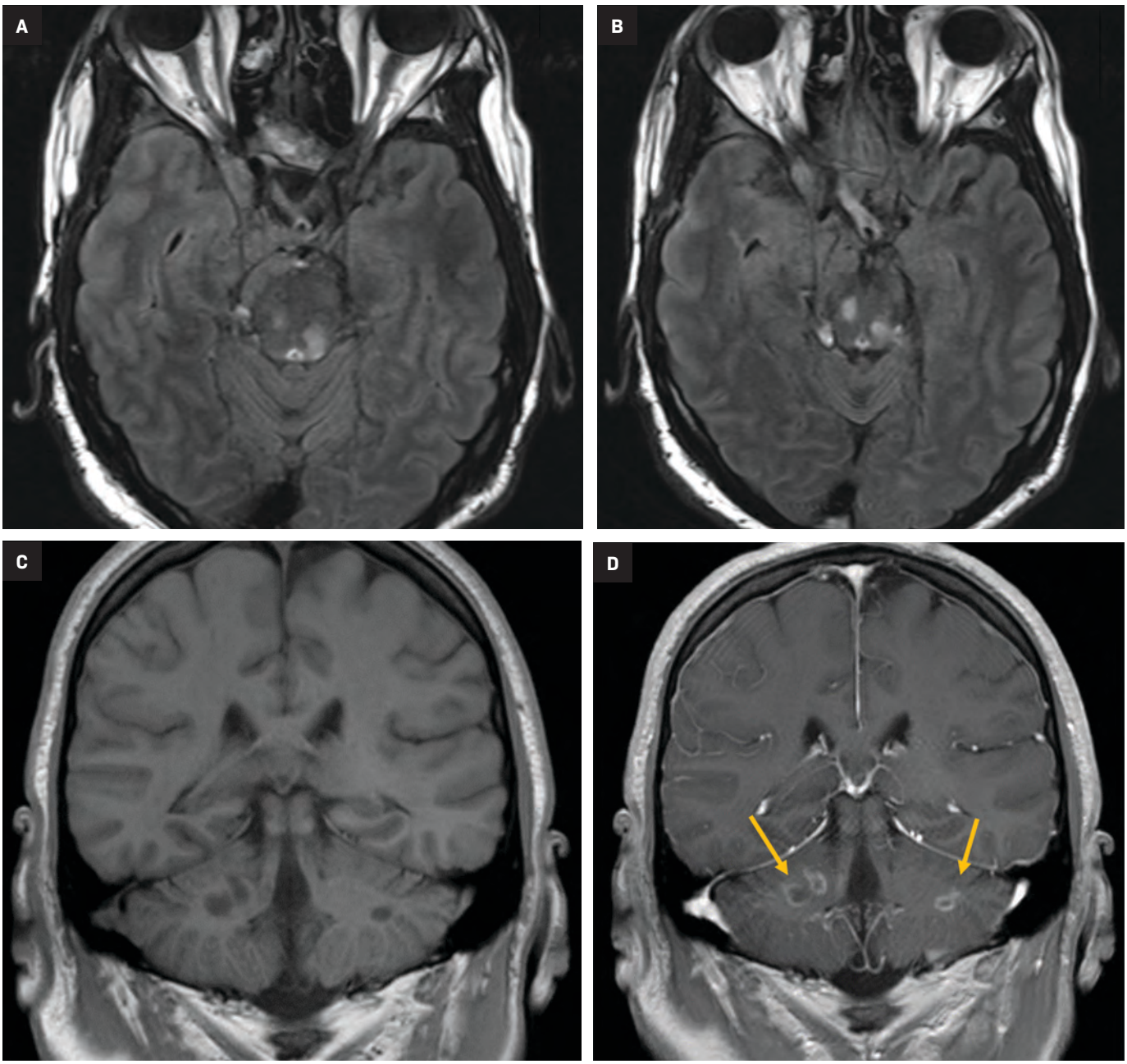
Diagnosis

Acute demyelination remote to the maximally targeted therapeutic field of radiation.

Follow-up

Following diagnostic biopsy, a 3-month follow-up brain MRI scan showed interval increase in the T2/FLAIR-hyperintense pontine lesions, but improvement in the known cerebellar ones. Clinical examination improved with noted residual left arm dysmetria and mild left hemiparesis. The next quarterly follow-up brain MRI scan showed a decrease in size of the known lesions without any contrast enhancement. The examination was stable and dexamethasone was being tapered. Subsequent follow-up, 11 months after the diagnosis, demonstrated stable

Figure 2. T2/FLAIR MRI sequences showing scattered pontine hyperintensities (A, B) with noncontracted and contrasted coronal T1 MRI sequence demonstrating cerebellar hypointensities with enhancement following gadolinium administration (arrows) (C, D).

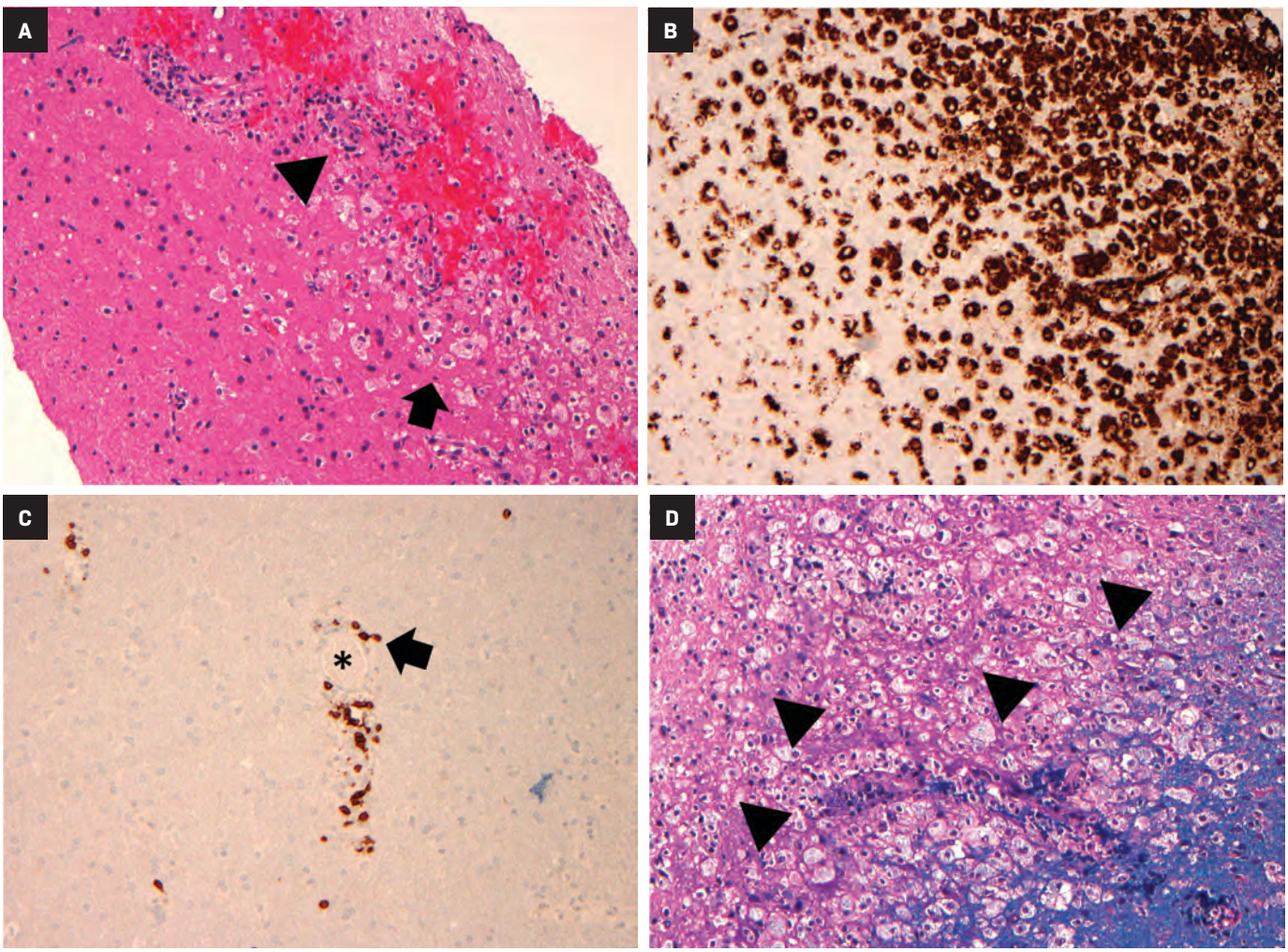


imaging and examination. Multiple endocrinopathies associated with the primary tumor and subsequent treatments have also been addressed and tracked with clinical and laboratory assessments. Euthyroid state has been achieved with levothyroxine, and testosterone injections are administered periodically. Somatostatin has been continued since the diagnosis. Insulin-like growth factor 1 (IGF-1) levels have decreased, dropping from initial value >1200 ng/mL to 525 ng/mL by the time of the most recent follow-up (84-270 ng/mL as normal range).

Discussion

Acute demyelination remote to the maximally targeted field remains a rare or under-recognized entity. The initial case was described in the setting of proton radiation therapy for optic nerve meningioma.[1] In a larger pediatric case series with the same treatment modality, several patients with asymptomatic white matter changes outside of the targeted area are mentioned, but additional diagnostics were not pursued.[2] A case of a decade-long, relapsing demyelinating process following whole-brain radiation showed findings suggestive of a demyelinating

Figure 3. Pathology slides with original magnification of 200X. Focal increased cerebellar white matter macrophages (arrow) and perivascular lymphocytes (arrowhead) in an area of demyelination (hematoxylin and eosin) (A). Macrophages in a focus of demyelination are highlighted with a CD68 immunostain (B). A CD3 immunostain highlights the presence of benign-appearing T cells (arrow) around blood vessels (asterisk) in an area of demyelination (C). A Luxol fast blue stain showed decreased staining corresponding to loss of myelin in the white matter (arrowheads, D).

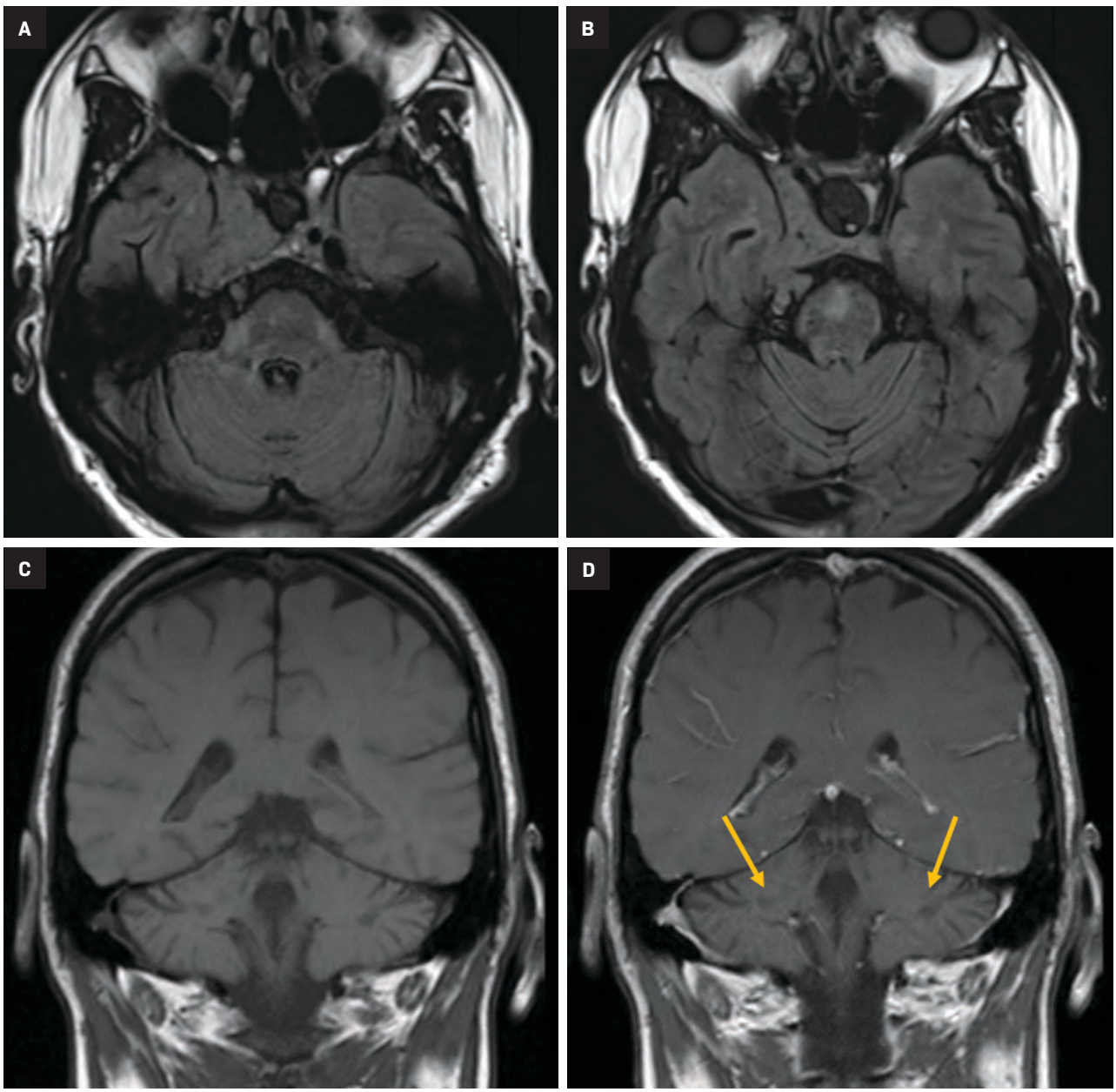


process on repeated biopsy, but also concurrent coagulation necrosis with the initial one.[3] A report of 2 patients with acute demyelination following radiation therapy for glioma was published, although unlike our patient, oligoclonal bands were seen in the cerebrospinal fluid (CSF) to establish this diagnosis.[4] Although the process was initially thought to be radiation necrosis in the currently presented case, it was clinically inconsistent with such a diagnosis given the short time frame and since much of the noted enhancement and edema were outside of the high-dose radiation field, though within the region receiving 2000 cGy. Biopsy confirmed demyelination rather than necrosis. All other reported cases with similar clinical-radiological features had negative diagnostics for primary demyelinating processes and responded well to steroids, with improvement on imaging and clinical examination.[1,3] Pathophysiology may involve direct radiation-related toxic effects on myelin, damage to blood-brain barrier and secondary inflammatory reaction, damage to small vasculature, or a multifactorial process triggering an autoimmune reaction.[5] Oligodendrocyte depletion is also speculated.[6] The pathophysiological role of elevated IGF-1 as an immunostimulant in certain autoimmune diseases is being investigated,[7] but current studies also point to its protective role in experimental autoimmune demyelination, possibly by enhancing the function of Treg lymphocyte subpopulations.[8] In this currently reported case, IGF-1 has remained elevated throughout the course, but with a considerable downtrend following surgery, radiation, and medical management with somatostatin.

Conclusion

Delayed acute onset demyelination in the setting of brain radiation therapy, though remote to the maximally targeted area, should be considered as a differential diagnosis in an

Figure 4. Interval decrease of previously noted lesions, demonstrating no enhancement (arrows) (A-D).



appropriate clinical scenario. A broad diagnostic workup would be warranted in such a case, with consideration of a biopsy as an ultimate clinical-pathological investigation. Immunosuppression with steroids appears to be an effective treatment, which is consistent with the findings from other series.

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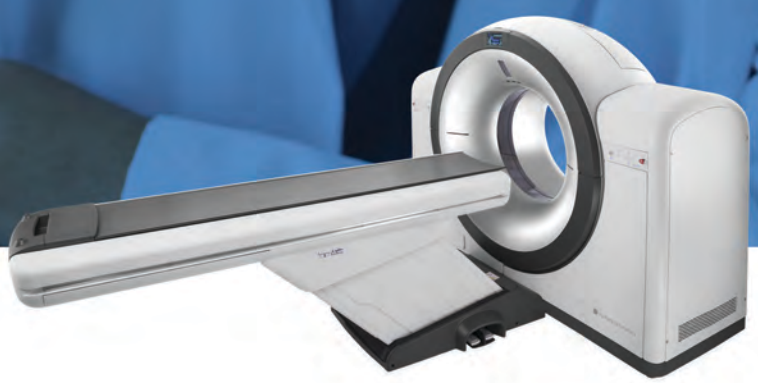

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High-Field MR-Guided Radiation Therapy for Oligometastatic Central Lung Cancer: Current State and Future Opportunities

Julius Weng, MD;[1] Abigael Odwuor, BA;[1] Jinzhong Yang, PhD;[1] Percy Lee, MD[1]

Case Summary

A 68-year-old never-smoker presented with a chronic cough for 1 year. A chest x-ray demonstrated a right upper lobe (RUL) mass-like consolidation and subsequent computed tomography (CT) of the chest confirmed a 7.8-×-4.6-cm RUL mass extending into the mediastinum (**Figure 1**). Needle biopsy revealed squamous cell carcinoma with PDL1 40% and MET exon 14 skipping mutation. Positron emission tomography (PET)/CT demonstrated oligometastatic disease with suspicious mediastinal lymphadenopathy and a 2.6-cm left iliac wing metastasis. Endobronchial ultrasound was negative for metastatic disease to nodal stations 7, 4, and 10R. MRI of the brain did not demonstrate concerning intracranial lesions.

The patient was started on carboplatin/paclitaxel/pembrolizumab for 1 cycle and developed a pruritic, full-body rash (grade 3) requiring steroids. He was subsequently enrolled on a clinical trial of tepotinib (MET inhibitor, NCT02864992). He received 6 cycles of tepotinib, but continued to have recurrent episodes of rash and scalp lesions that prompted frequent treatment interruptions. After receiving 4 months of tepotinib, he ultimately developed progressive disease in the thorax and tepotinib was discontinued. He was evaluated in the thoracic radiation oncology clinic and the recommendation was made for local consolidation therapy with concurrent chemoradiation. He received 52.5 Gy/15 fx to the RUL primary, which is one of the most common regimens at our institution for consolidative thoracic therapy for oligometastatic disease, and was

Figure 1. Initial CT: 7.8-cm right upper lobe (RUL) lung mass invading the mediastinum and abutting the trachea

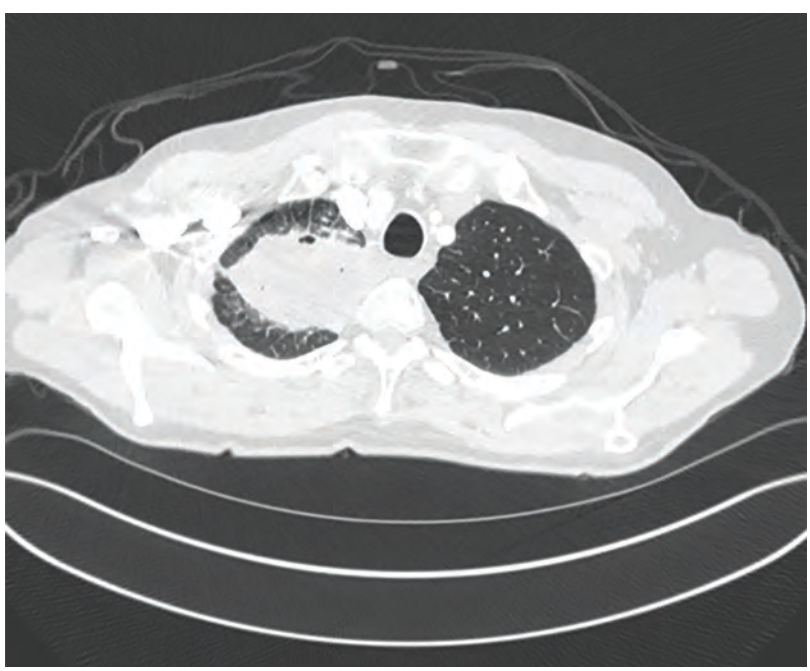

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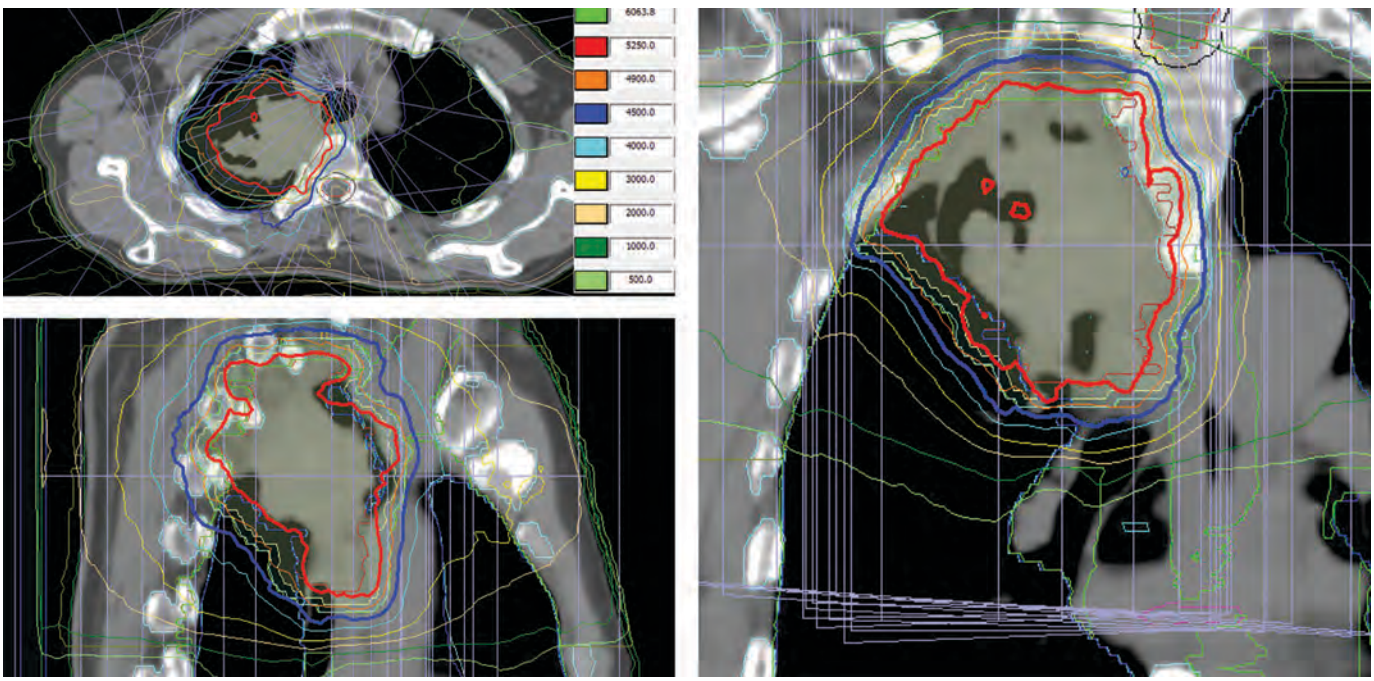
Figure 2. Initial plan on MR-linac



included on the non-small cell lung cancer (NSCLC) local consolidation therapy study by Gomez et al.[1] He also underwent 27 Gy/3 fx to his left iliac wing metastasis.

Given the central location of his primary tumor and proximity to critical structures such as the trachea, his RUL primary was treated on a 1.5 Tesla MR linear accelerator (MR-linac).

Simulation included a CT scan on a Philips Brilliance 16-slice CT scanner followed by MR scans on the MR-Linac. He was immobilized with an MR-compatible Vac-Lok cushion. The lung 4D CT scan protocol was performed at CT simulation. Average 4D CT was reconstructed for treatment planning, with image resolution of 1 × 1 × 2.5 mm. The MR scans included both 3D T1- and T2-weighted sequences, with reconstructed image resolution of 1 × 1 × 1.2 mm.

Target contouring was performed based on a combination of 4D CT, PET, and MRI by taking into account the uncertainty from respiratory motion. The target volume included all gross disease as defined on CT, PET and MRI with a 5- to 7-mm clinical treatment volume (CTV) and 5-mm planning treatment volume (PTV). Organs at risk (OARs) were contoured on CT for lungs, heart, esophagus, spinal cord, brachial plexus, and chest wall.

The reference plan was done on the average 4D CT in the Monaco treatment planning system (Elekta). A step-and-shoot intensity-modulated radiation therapy (IMRT) plan was developed for treatment with the Elekta Unity MR-linac with beam energy of 7 MV flattening filter free. Twelve beams were used, with beam angles of 30, 0, 340, 320, 300, 280, 260, 240, 220, 200, 170, and 150. The dose calculation uses a graphics processing unit (GPU)-based Monte Carlo algorithm with a variance reduction technique.[2] The dose grid was set to 3 x 3 x 3 mm^3 and the statistical uncertainty of the Monte Carlo algorithm is 1%. A total dose of 52.5 Gy was prescribed to cover at least 95% of the envelope of respiratory motion of gross tumor volume (GTV) in 15 fractions (**Figure 2**). The final reference plan has a total of 1100 monitor units and 98 segments. Achieved target and normal tissue doses are depicted in **Figure 3**.

The quality assurance (QA) for the pretreatment patient chart followed the same guidelines for conventional linac treatments, including a secondary MU verification using RadCalc (Lifeline Software Inc.) and IMRT QA measurement using ArcCheck MR phantom (Sun Nuclear Corporation).

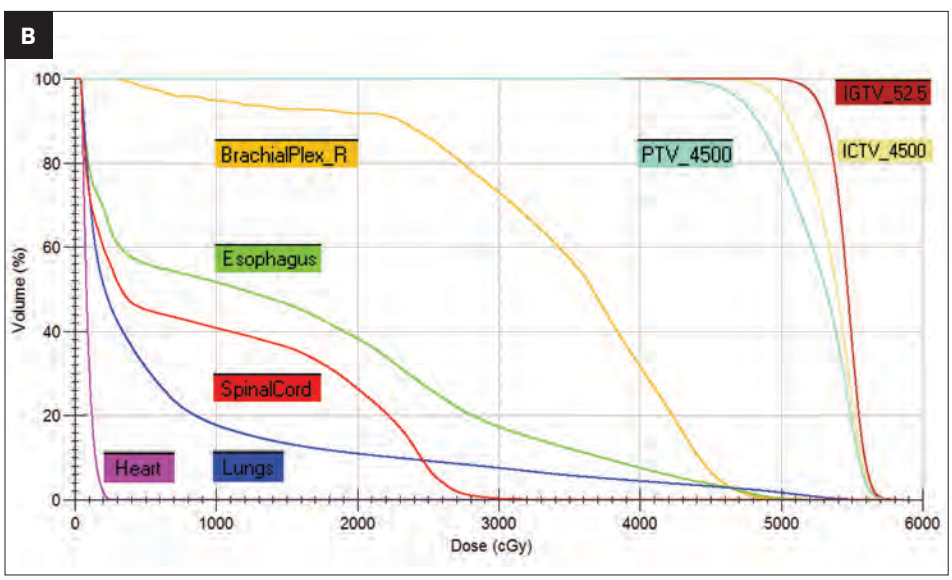
For each treatment fraction, the patient was set up to the couch index location recorded at simulation. There is no external laser in the MR-linac treatment room. The patient setup relied on an internal sagittal laser and leveling marks on patient surface. A 3D T2 MRI scan was acquired with an acquisition time of 2 minutes. This MR scan was rigidly registered to the simulation CT scan of the reference plan, accounting for the isocenter shifts in left-right (LR), anterior-posterior (AP), and superior-inferior (SI) directions. **Figure 4** shows the statistics of the shift values of all 15 fractions. An adaptive plan was then created based on an "adapt to position (ATP)"

Figure 3. Initial plan dose statistics (A) and dose-volume histogram (DVH) (B)

A

Structure	Dosimetric Criterion	Actual Value	
IGTV_52.5	V5250cGy > 95 % (-2 %)	95.01 %	✓
PTV_4500	V4500cGy > 95 % (-3 %)	98.59 %	✓
Lungs	V2000cGy < 35 % (+2 %)	10.92 %	✓
	V1000cGy < 45 % (+2 %)	17.71 %	✓
	V500cGy < 65 % (+2 %)	31.51 %	✓
	Dmean < 2000 cGy (+10 cGy)	708.9 cGy	✓
Esophagus	V5000cGy < 40 %	0.33 %	✓
	Dmean < 3400 cGy (+100 cGy)	1503.4 cGy	✓
	Dmean < 3400 cGy (+100 cGy)	1503.4 cGy	✓
SpinalCord	Dmax < 3600 cGy (+3 cGy)	3372.1 cGy	✓
Chestwallnew	V4000cGy < 150 cm³ (+30 cm³)	140.673 cm³	✓

B



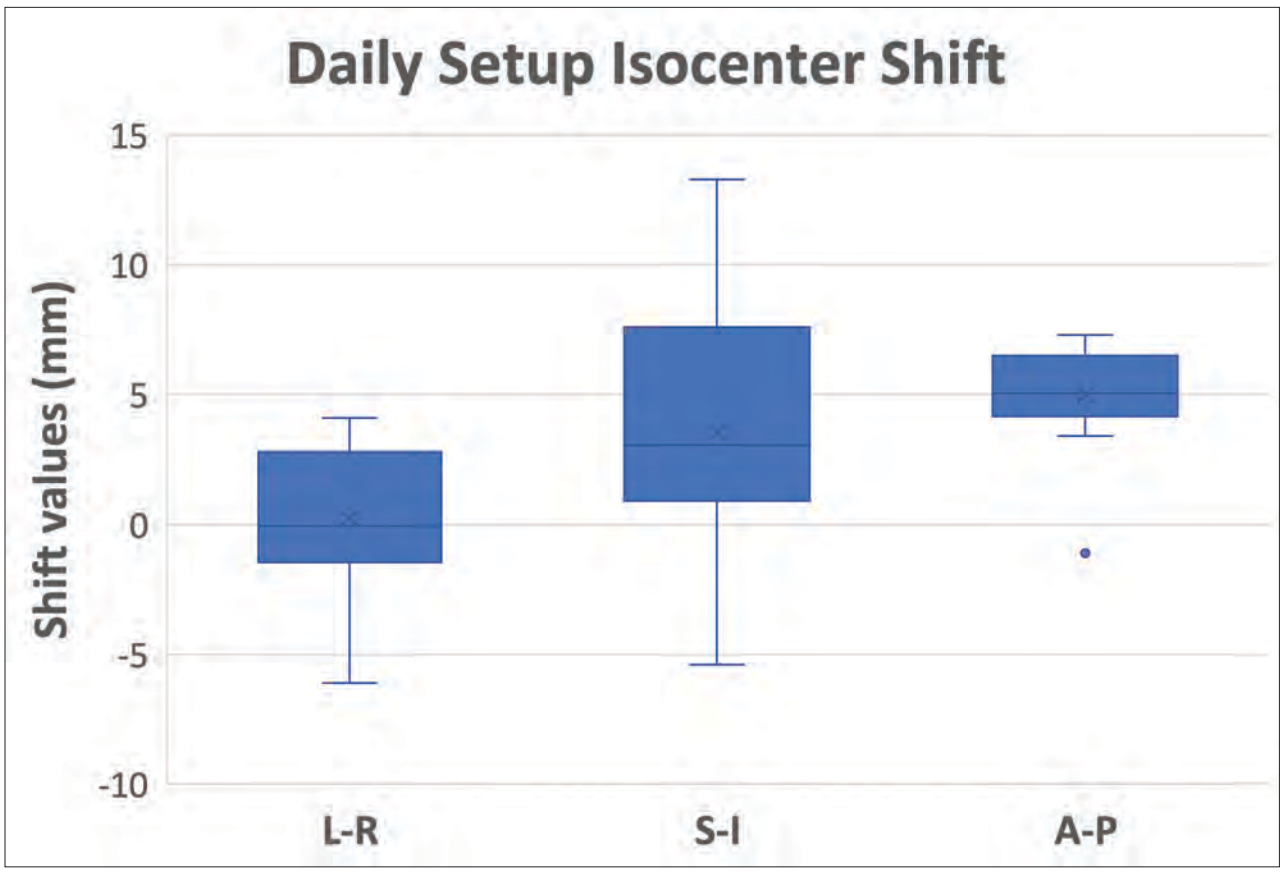
approach. Specifically, the plan isocenter defined on the reference CT plan was virtually "shifted" to a new location on the CT scan based on isocenter shifts determined by the MR/CT registration. The original reference plan was then re-optimized to ensure that target and normal tissue planning constraints were met or maintained (**Figure 5**). Once the adaptive plan was accepted by the attending physician, a secondary MU check of the adaptive plan was performed before the plan was transferred to the linac console for delivery. On average, treatments were 35 minutes from patient in room to treatment completion.

After all fractions were delivered, we performed dose accumulation of daily adaptive plans to evaluate the dosimetric accuracy of the ATP approach, which is often considered suboptimal because daily anatomy difference was not accounted for during plan adaptation. Each ATP plan dose was scaled down to 1 fraction and added together to create a summed dose, which represented the planned delivered dose. At the same time, the fraction dose of each ATP plan was shifted to the corresponding MR image and deformed back to the reference CT image for accumulation by using an in-house deformable registration tool.[3,4]

The accumulated deformed dose approximated the actual delivered dose by accounting for daily anatomic variations. By comparing the accumulated deformed dose with the summed plan dose, target dose difference is less than 1% for gross tumor volume, clinical target volume, and planning target volumes (**Figure 6**). Most OARs have a small dose difference, except the trachea receiving 10% more dose (3.3 Gy) and esophagus receiving 7.2% more dose (1 Gy). Dose distribution was compared in **Figure 7**. This demonstrates the potential benefit for using a truly adaptive process accounting for daily anatomical variation, adapt to shape (ATS), in the future. This is particularly the case if planned doses were higher and delivered using a stereotactic ablative approach in the future for central and ultracentral tumors to reduce tracheal and esophageal doses.

The patient tolerated radiation therapy (RT) well with a grade 2 cough and esophagitis during treatment. After RT, he had a persistent mild cough and dyspnea on exertion not requiring steroids. After RT, he received 3 cycles of consolidative carboplatin and taxol. PET at 3 months demonstrated partial response of the treated lesions (**Figure 8**), but also revealed suspicious hypermetabolic right, anterior pleural/chest wall lesions. On follow-up, his chest wall metastases became symptomatic and he was also found to have mediastinal progression inferior to the prior RT field, and new right lung nodules. He underwent 2 months of capmatinib and palliative RT to his chest wall metastases (30 Gy/10 fx). Although his pain improved, he continued to progress and was subsequently enrolled on a trial of Tisotumab vedotin with partial response but developed Guillain-Barre requiring intravenous immunoglobulin. He subsequently was enrolled on a trial of a MDM2

Figure 4. Isocenter shifts in left-right (LR), anterior-posterior (AP), and superior-inferior (SI) directions



inhibitor with Taxol, but ultimately progressed and received palliative radiation to his left femur (12 Gy/1 fx) and lumbar spine (24 Gy/1 fx). On the most recent follow-up approximately 1.5 years after initial RT, he had transitioned to hospice care.

Diagnosis

Squamous cell carcinoma, PDL1 positive (40%), MET exon 14 skipping mutation

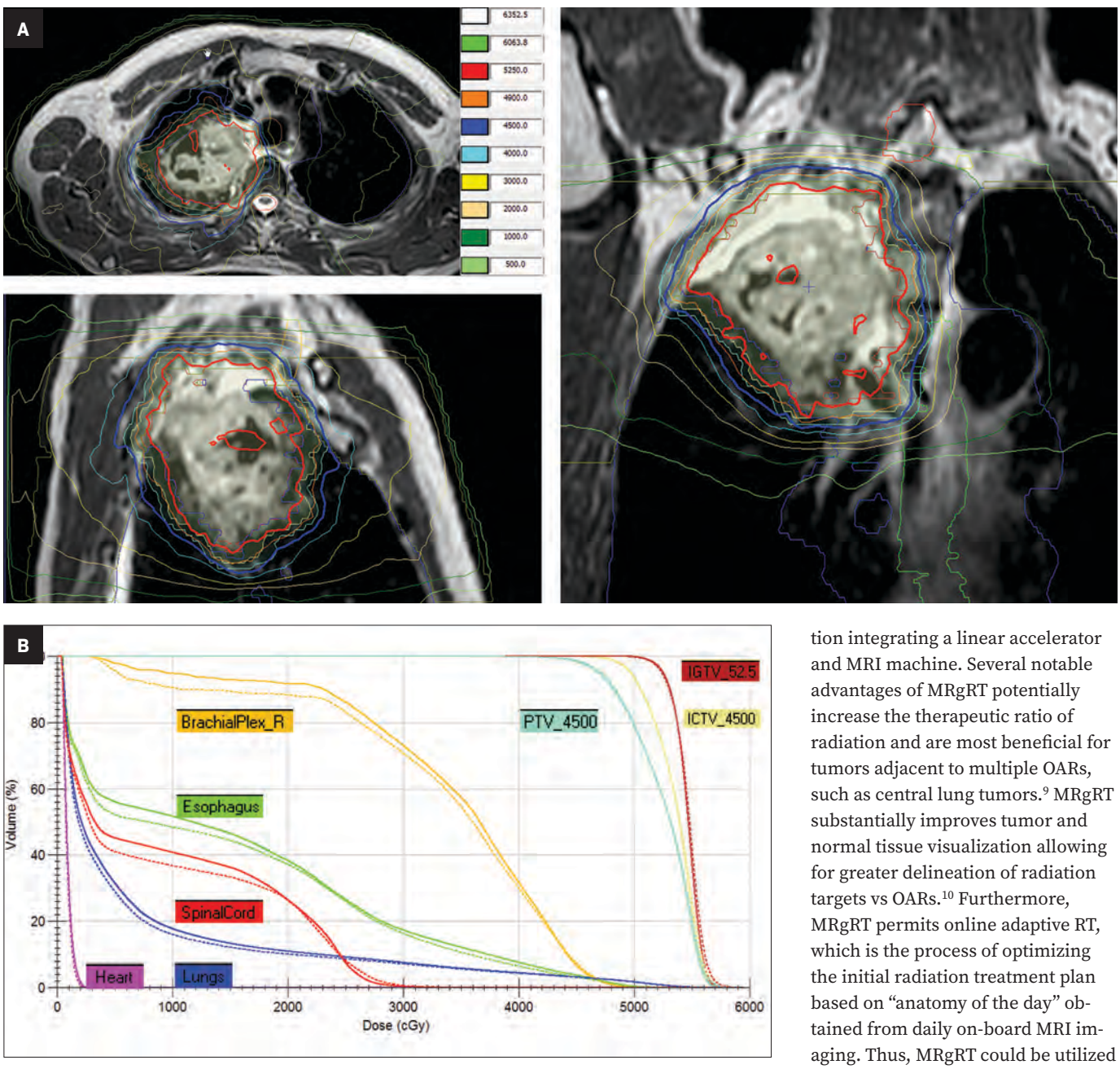
Discussion

The term oligometastatic disease refers to a distinct clinical state involving 1 to 5 metastases that are amenable to local therapies.[5] Between 25% and 50% of metastatic NSCLC patients initially present with oligometastatic disease.[6]

A growing body of evidence suggests that consolidating all known sites of oligometastases with RT may increase progression-free survival (PFS) and overall survival (OS). In a multi-institutional, phase II trial, 49 NSCLC patients with ≤ 3 metastases were randomized to standard-of-care systemic therapy ± local consolidation therapy (LCT).[1] The study was closed early by the data safety and monitoring board after interim analysis demonstrated significant PFS benefit. After a median follow-up of 39 months, there was also an OS benefit of 41 vs 17 months in favor of the LCT arm. Another phase II trial, SABR-COMET,[7] randomized 99 patients with ≤ 5 metastases to standard-of-care systemic therapy ± LCT. This study enrolled patients of various histologies, including 18% with NSCLC. After a median follow-up of 51 months, the 5-year OS in the LCT arm significantly improved (42% vs 17%). Although these studies and others have demonstrated the benefit and relative tolerability of LCT, there remain risks of consolidative RT. On SABR-COMET, 3 patients (4.5%) died as a result of treatment-related toxicity—2 cases of which were related to lung-directed RT.

In radiation oncology, central lung tumors are typically defined as lesions within 2 cm of the proximal bronchial tree and are associated with the highest rate of pulmonary RT complications. This is due to the proximity of tumor to critical structures including the trachea, esophagus, heart, and great vessels. The challenges of treating central lung tumors also derive from difficulty in delineating tumor from soft tissue with conventional CT imaging, which

Figure 5. Dose distribution of 10th fraction overlaid on the daily MR scan (same isodose lines as reference plan) (A). Dose-volume histogram (DVH) comparison between the adaptive plan (solid lines) of the 10th fraction and the reference plan (dashed lines) (B). The DVH illustrates reduction of normal tissue doses while maintaining planning treatment volume (PTV), internal gross tumor volume (IGTV), and clinical treatment volume (CTV) coverage.



increases uncertainty of appropriately achieving OAR dose constraints. As a result, at our institution[8] we generally recommend hypofractionated RT regimens as opposed to stereotactic body radiation (SBRT) for bulky central lung tumors as described in the aforementioned patient case. Given the promising results of definitive doses of consolidative RT for oligometastatic disease, the reduction of OAR doses while maintaining a high biologic effective dose (BED) would represent a meaningful advance in the treatment of central NSCLC.

MR-guided radiation (MRgRT) is a significant technological innovation integrating a linear accelerator and MRI machine. Several notable advantages of MRgRT potentially increase the therapeutic ratio of radiation and are most beneficial for tumors adjacent to multiple OARs, such as central lung tumors.[9] MRgRT substantially improves tumor and normal tissue visualization allowing for greater delineation of radiation targets vs OARs.[10] Furthermore, MRgRT permits online adaptive RT, which is the process of optimizing the initial radiation treatment plan based on "anatomy of the day" obtained from daily on-board MRI imaging. Thus, MRgRT could be utilized to adapt treatment plans to ensure that OAR constraints are met during each fraction. MRgRT also allows for continuous, real-time imaging during radiation delivery, which allows for tracking of intrafraction tumor motion due to respiration. In addition to motion management, real-time imaging provides assurance that adequate dose was delivered to

Figure 6. Dose-volume histogram (DVH) comparison of summed plan dose (dotted lines) and accumulated deformed dose (solid lines). The DVH illustrates the good consistency between planned dose and estimated actual received dose for target and most organs at risk (OARs), except the trachea and esophagus, which might be due to the motion from fraction to fraction.

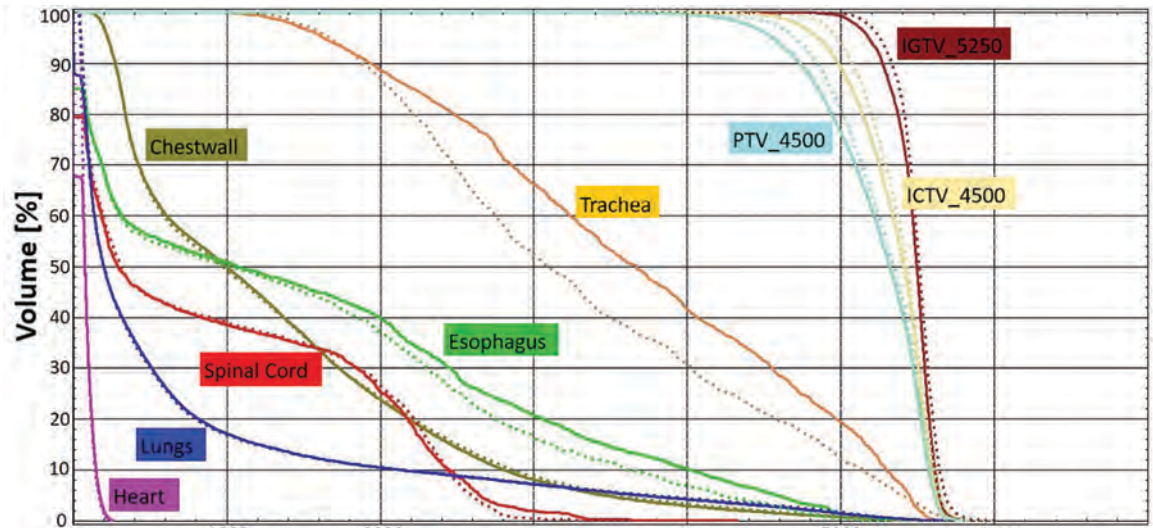
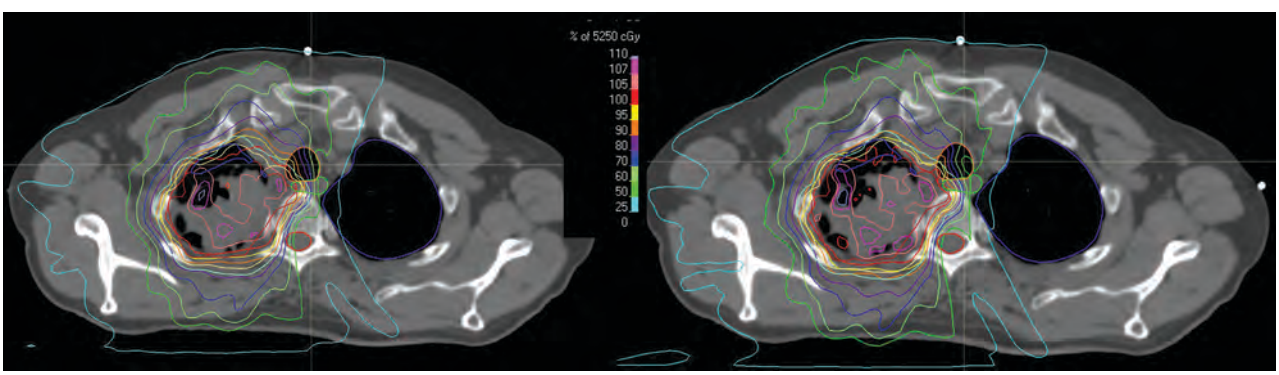


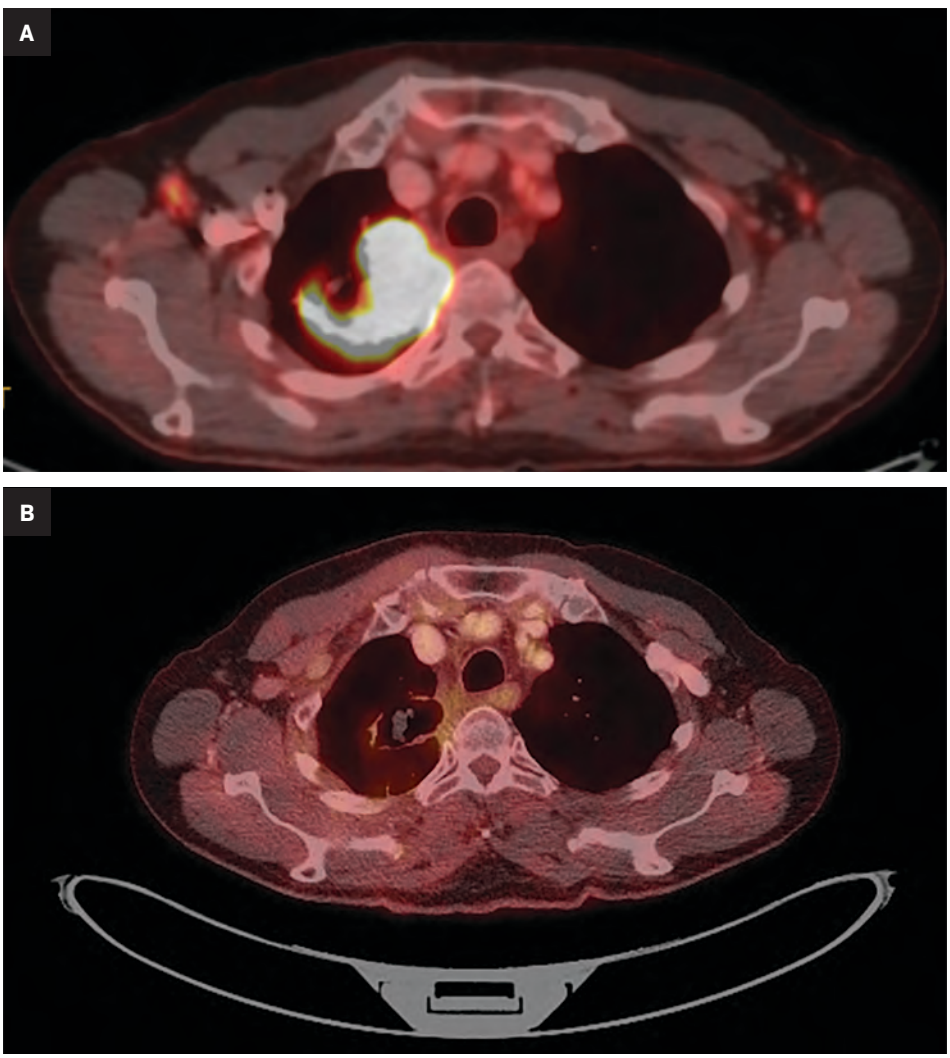
Figure 7. Dose distribution on one axial slice for accumulated deformed dose (A) vs summed plan dose (B).



the target and that OARs were appropriately spared. Currently, 2 MRgRT devices for treating patients are commercially available, the ViewRay MRIdian and Elekta Unity. Comparison of the technical specifications are illustrated in **Table 1**. Granted, as one of the first thoracic cases treated with an MRgRT approach at our institution, as well as some of the current technical limitations of the device in terms of active motion management, this case is intended to illustrate the workflow, image quality, and potential for use of this technology in the future to improve upon outcome for treatment of thoracic malignancies with MRgRT. We intend to treat other patients with central/ultracentral lung tumors with a similar workflow as part of a prospective phase I clinical trial.

Although there are multiple ongoing clinical trials of CT-based SBRT for central lung tumors, few studies have evaluated the role of MRgRT with daily adaptive plans for these patients. An initial simulation trial of MR-guided hypofractionated RT for 12 central thoracic tumors demonstrated improved PTV coverage and OAR sparing with use of midtreatment adaptive planning.[11] This was followed by a phase I trial of stereotactic MRgRT using online adaptive RT for ultracentral thoracic tumors.[12] In this study, 5 patients underwent MRgRT with 50 Gy/5 fractions and 4 patients required at least 1 adapted fraction to either improve PTV coverage or reverse OAR violations. At 6 months, local control was 100% and there were no grade ≥ 3 toxicities. A larger, retrospective study reviewed outcomes using stereotactic MRgRT for 50 consecutive, high-risk thoracic tumors (central location, prior RT, and interstitial lung disease).[13] This study reported low rates of toxicity (grade ≥ 3 8%) and 1-year local control of 96%. Overall, the aforementioned trials demonstrate the feasibility and potential benefit of MRgRT. Notably, they used the ViewRay MRIdian, which is a low-field MR device as opposed to high-field MR with the Elekta Unity.

Figure 8. Positron emission tomography (PET) pre-RT. Right upper lobe (RUL) lung mass measures 7.7 cm with a standardized uptake volume (SUV) max 41.3 (A). PET 3-month post-RT: RUL lung mass now measures 4.8 cm with decreased SUV max (6.4) (B).



As the MR-linac is a relatively new device, drawbacks remain to MRgRT such as dosimetric impact of magnetic field effects on secondary electrons, suboptimal imaging of small parenchymal lesions due to low proton density of lungs, and the need for optimization of real-time motion management. To better characterize the potential benefit of MRgRT for patients with central NSCLC, we plan to conduct a 2-part clinical trial of MRgRT for patients with central NSCLC. First, we will assess the potential dosimetric benefit of MRgRT with simulated online adaptive planning. The initial cohort of patients will undergo daily onboard MR imaging that will be used to simulate adaptive plans, which will be compared to the actual delivered plan. Clinical and imaging characteristics will be assessed to identify patients most likely to benefit from MRgRT. The second cohort of patients will undergo treatment on the MR linac with online adaptive planning, reduction of fraction numbers from hypofractionation to SBRT whenever feasible, and prioritizing strict daily fractional OAR doses for each fraction. Given the advantages of MRgRT, we hypothesize that MRgRT will permit delivery of high biologically effective dose (BED) for

Table 1. Technical Comparison of Elekta Unity and ViewRay MRIdian

	Radiation source	Radiation modulation	Dose rate	Field size	Configuration	Bore size	Magnetic field orientation	Magnet strength	Acquisition time	MRI sequences	Cine image frame rate	Motion management
Elekta Unity	7MV FFF	Single stacked MLCs, leaf width 7.1 mm	425 MU/min	57.4 x 22 cm^2	Superconducting close bore	70 cm	Perpendicular	1.5 T	2-7 min, fast BH scan (11 sec) pending	T1 weighted, T2 weighted, DWI	4-6 frames /sec	Motion monitoring, automatic beam gating and tracking pending
ViewRay MRIdian	6MV FFF	Double stacked MLCs, effective leaf width 4.15 mm	600 MU/min	27.4 x 24.1 cm^2	Split superconducting close bore	70 cm	Perpendicular	0.35 T	< 3 min, fast 17 sec	T1 weighted, T2 weighted, DWI bSSFP	4-8 frames /sec	Motion monitoring, automatic beam gating

Key: FFF = full-field fractionation, MLCs = multileaf collimators, DWI = diffusion-weighted imaging

central tumors without excessive rates of toxicity.

Conclusion

Oligometastases are common for patients with NSCLC and local consolidation therapy with radiation may be an effective treatment strategy. However, central lung cancers remain a challenging tumor site given the close proximity to multiple critical OARs. MRgRT provides several advantages over conventional CT-based treatment including improved tumor delineation, potential for daily adaptive plans, and real-time imaging. These benefits may improve the therapeutic ratio of RT and enable achievement of high BED without severe toxicity. Further investigation is warranted, and we plan to conduct a clinical trial of MRgRT for central lung cancer at our institution.

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Critical Steps During Residency: Advocating for Our Future

Brian Bingham, MD

"Focus on the step in front of you, not the whole staircase."

In certain situations—running a marathon, learning an instrument, contouring your first head-and-neck case—this may be wonderful advice. In others, however, heeding this counsel might lead to unintended consequences. Indeed, failure to remember the entire picture can sometimes leave us falling short. I am reminded of this every time I plant a garden. No matter how well I weed and fertilize, my seeds will never survive if I fail to check the forecast for an upcoming freeze.

In some ways, I worry that a similar mistake can happen during residency. Do we sometimes focus so much on the tasks immediately in front of us that we forget the larger context? How often do we stop and ask, "Where is all this training taking me anyway?"

Unfortunately, such moments are too few and far between and this failure to contextualize our training could profoundly affect our field. In particular, resident physicians who fail to engage in the legislative changes occurring in radiation oncology may be surprised to find that their profession has changed significantly once they graduate. For example, during the past 2 years alone, our field has experienced an unprecedented relaxation of radiation therapy supervision requirements, major proposed decreases in Medicare reimbursement, and implementation of the Radiation Oncology Alternative Payment Model. These changes will impact our field for decades. Yet, how many of us with decades left in our careers are aware of them?

Although the fundamentals of graduate medical training must always be clinical knowledge and technical skill, resident physicians cannot afford to take a back seat while others shape the future of our profession. Fortunately, there are myriad ways to avoid falling into this trap. For example:

1. We can become better informed about key legislative issues. In doing so, summaries produced by professional societies can be extremely helpful. Further, residency didactics can be expanded to include discussions of pertinent issues and policies.
2. We can participate in advocacy through formal events (Advocacy Days, etc.) and communication with local and state legislators (email, social media, etc.). Again, leveraging our membership in professional societies can be extremely effective as they often have mechanisms in place for physicians to participate. On a personal note, I have learned that physician involvement in advocacy is much easier than we might anticipate. Most often, a willingness to share our clinical expertise and personal experiences is all that is needed.
3. We can discuss policy issues and upcoming legislation with those around us. By necessity, advocacy is a team sport, and the more participation we can foster in others the more successful we will be.

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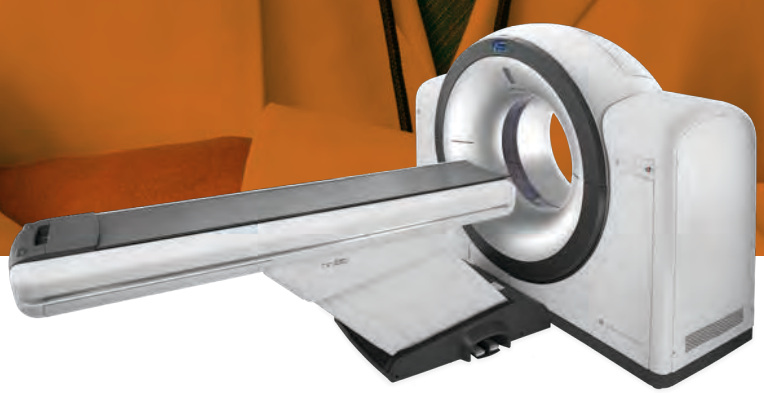

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