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RESEARCH ARTICLE

Radiation Oncology-Future Vision for the Modern Radiation Oncologist

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ABSTRACT
Radiation oncology has evolved as a discipline and the physicians who practice radiation oncology are adapting to the changing landscape of oncology management. The skill set for the modern radiation oncologist has matured as the requirements for modern patient care have become increasingly complex both in patient evaluation and treatment execution. Radiation oncology interacts with all medical and surgical subspecialties and advanced radiation therapy treatment plans require nimble use of volumetric anatomic and metabolic image sets and applied pathology to contour targets for successful treatment. Although multidisciplinary care management can serve to confirm and validate a treatment plan among providers, the number of providers involved with an individual patient management plan can also generate confusion and mixed messaging for the patient and their family. Because radiation oncologists work with every discipline and see patients weekly on treatment, often the relationship between the radiation oncologist and the patient can serve as a bridge between disciplines and radiation oncologists can serve to align the disciplines with the patient to re-affirm the care plan, limit confusion, and generate confidence for the patient with the plan and the providers. In this article, we will review the changing role of the radiation oncologist as we continually move directly into the mainstream of patient care, in equal partnership to medical oncology with highly advanced tools for modern therapy. Survivorships models of care will mature as radiation oncologists become more integrated into primary and follow up management of each cancer patient. The article has relevance as modern radiation therapy programs will need to adjust to meet the needs of modern patient care as radiation oncologists assume more primary responsibility for the longitudinal care of the oncology patient.

Keywords: Radiation oncology, Patient care, Survivorship, Advanced technology, Care management, Theranostics

Introduction

The first generation of trainees in radiation oncology in the United States used fluoroscopy as a primary planning tool coupled with a fundamental understanding of the relationship between location of primary disease and potential areas of tumor spread including patterns of failure to define a therapy treatment plan. Planning tools were limited and could only be applied largely at the isocenter of a target with limited ability to adapt to sloping surfaces and changes in both surface anatomy and anatomy at depth throughout the target volume. Colleagues in medical oncology maintained strong skill sets in physiology and pharmacology while radiation oncologists had strengths in anatomy and radiology. Although board certification was and remains housed with the American Board of Radiology (ABR), radiation oncologists rapidly matured in separate training programs which included direct and longitudinal patient contact. Although early radiation oncologists were thought to be performing procedures on cancer patients similar to our diagnostic colleagues, our medical oncology colleagues altered this perspective and preferred we work side by side with them in the practice of oncology. With surgical and medical oncology colleagues, the interactions created the first iteration of multidisciplinary care. Radiation oncologists matured in this hybrid model supporting procedural care for the patient yet at the same time providing longitudinal care for the patient and their family. Although radiation oncologists were not often responsible for primary interactions with the patient, radiation oncologists often had to help confirm for the patient and family the overall plan and make certain supportive comments were in alignment with the objectives of the multidisciplinary team.

With the advent of volumetric radiation oncology treatment planning including the routine use of computer tomography as part of the simulation process, expectations of the skill set required for radiation oncology forever changed. In a brief period of time, radiation oncologists were expected to be expert in the application of imaging and radiomic features. Diagnostic colleagues often placed priority on the presence or absence of lesion or mass, radiation oncologists needed to ask different questions as we need to know the length, width, and depth of the mass and define targets based on the probability of tumor control and dose to targets defined as high, intermediate, and low risk volumes juxtaposed to critical normal tissues, defined and contoured for conformal avoidance. Three-dimensional modeling provided radiation oncologists an opportunity to be secure in defining dose to a tumor volume and defining radiation dose to a normal tissue volume. In this capacity the skill set evolved as radiation oncologists had to define and optimize dose to target as well as set limits or constraints to the dose delivered through the plan to a volume of normal tissue. This process has brought radiation oncologists further away from all other disciplines as the language of therapy has evolved to become our own basis for department communication not shared with other disciplines. We provide predictive indices for dose to normal tissue volumes in written directives unlike any other sub-specialty discipline. Our quality assurance processes are rigorous and disciplined without comparison to other sub-specialties. Our plans are exceptionally precise and can be reproduced with confidence. Unlike delivering a drug, we know where dose is delivered, and we can validate delivery through multiple venues pre-therapy in real time. We have become excellent study investigators and maintain discipline to our science, yet we also maintain longitudinal relationships with patients, both new and established, not uniformly seen in other medical and surgical sub-specialties. Radiation oncology has become a strong role model for academic physicians practicing in clinical and scientific hybrid models.

The radiation oncologist of today has to have a broad and robust skill set to practice modern radiation oncology. Although programs and institutions place emphasis on disease-based activity, every practicing radiation oncologist maintains skill to apply therapy to patients of all disease sites when the situation requires rapid intervention for an unanticipated event including sites of oligometastatic disease within multiple disease groups. Today, if a patient is admitted to a hospital and requires a therapeutic intervention, the majority of time the intervention requires radiation therapy. Chemotherapy is not frequently used in the inpatient setting except for leukemia, bone marrow transplant, or an unanticipated crisis associated with rapid disease progression, therefore inpatient therapeutic intervention is largely focused on therapeutic radiation. Even patients treated with palliative intent often must have sophisticated treatment plans to provide minimal dose to tissues previously treated, therefore treatment plans even for inpatient management often require maximal use of department resources and expertise.

As our technology improves and we treat targets that are smaller and to high dose, radiation

oncologists are assuming more responsibility for follow up care. Radiation therapy can leave changes on post therapy images in all disease areas, often the radiation oncologist is responsible for interpreting the outcome images obtained on patients in juxtaposition to the treatment plan. Radiologists can only interpret what they see. Radiation oncologists interpret the image through the prism of the treatment plan which provides credibility to the interpretation of the outcome image. As patients are living longer including those with oligo metastatic disease, the radiation oncologist now plays a larger role in image interpretation and outcome management. Accordingly, radiation oncologists are essential to the follow up and after care of patients and now play an equal role to colleagues in medical oncology in patient management in multiple disease areas.

In this article, we review the changing role of the radiation oncologist in multiple disease areas as well as where radiation oncology and practitioners support cancer survivorship programs as this effort becomes more commonplace for patient management.[1-5]

In the next section, disease areas which are undergoing change reflecting the importance of participation by radiation oncologists are described recognizing these changes are beginning to affect each disease site.

Central Nervous System

There has been a significant shift in the management of patients with both primary and secondary tumors of the central nervous system. Targeting for patients with low grade and high-grade adult and pediatric primary brain tumors has evolved into a complex exercise in applied anatomic and metabolic image sequences with careful attention to tumor targets and dose/volume impact to normal tissues. Fusion of magnetic resonance (MR) images sequences and metabolic studies including amino acid positron emission tomography studies permit accurate targeting of tumor with dose painting to selected targets. Contouring targets with accuracy can take several hours especially when the radiation oncologist intends to deliver differential doses to selected targets. Often in this situation, the radiation oncologist may deliver different doses as part of a single plan to targets defines by spectroscopy, fluid attenuated inversion recovery (FLAIR), and T1 with contrast with increasing dose. If positron tomography imaging is available with an amino acid tracer, this target can receive a fourth dose as a site of deoxyribonucleic acid (DNA), synthesis. In reality, historical targets define by CT with contrast and early MR sequences may have under appreciated the extent of disease, particularly along the corpus collosum which provides a conduit to the contralateral hemisphere. Objects such as the chiasm, visual pathways, and auditory apparatus are contoured for conformal avoidance with constraints written to accommodate the goals and objectives of the plan. For treatment execution, a planning target volume (PTV) is applied to accommodate for possible variability in patient set up. Image guidance tools including optical tracking have considerably improved over the past decade and have influenced the volume and titration of the PTV. This has permitted decrease dose to normal tissue when appropriate, manage expectations, and accordingly define areas that merit more careful attention as part of survivorship planning beyond interpretation of outcome imaging. Very few diseases affect the wellbeing and personality of patients as those afflicted with brain tumors. These patients often require considerable support including at home skilled professionals to manage their needs and the needs of the family caring for the patient. This often is a shared responsibility between neuro-oncology and radiation oncology, however in institutions with limited neuro-oncology support, the post treatment support and image review are often managed through radiation oncology with protocol and chemotherapy support managed through medical oncology. Pediatric patients require additional areas for support often including, but not limited to, education and endocrine support as well as other areas best determined by the area treated and deficits created by the anatomical location of the tumor.

For patients with metastatic disease, more patients are being treated to limited target volumes which are specifically disease directed including treatment of multiple lesions with a single mono-isocentric radiosurgery and stereotactic radiation therapy plans. These techniques have matured with improvements in MR target definition and our ability to reproduce positioning on a daily basis for stereotactic therapy. There is less intentional whole brain therapy delivered today than previous with the exception of leptomeningeal disease which continues to require therapy to traditional targets involving the meningeal surface. Because smaller volumes are treated, radiation oncology takes the responsibility of ordering and following post therapy imaging for assessment of disease status and image interpretation, therefore follow up with these patients has become important for radiation oncologists performing stereotactic therapy. In most

departments, stereotactic therapy has evolved into part of the daily workflow and is no longer considered a unique or eclectic service. In fact, stereotactic therapy has become commonplace and often is 10-20% of daily activity in the modern department with radiation oncologists providing a significant component of follow up and post therapy care including management of steroids and memantine.

The role of the radiation oncologist is changing in managing patients with disease in the central nervous system. Aside from traditional areas of patient assessment, plan development, and treatment execution, the post therapy care is evolving into a shared responsibility with colleagues for image interpretation and medication management. These changes reflet the skill set of the modern radiation oncologist which is often not captured by traditional productivity metrics.[6-13]

Head/Neck

This is an area undergoing rapid change involving the role of the radiation oncologist in clinical management. These patients often present to clinic care with multiple needs that must be addressed in a timely manner to help expedite their care. The immediate care needs include nutritional/hydration support, dental care, and staging. When chemotherapy was introduced to clinical management as induction therapy, much of the initial medical management and completion of staging centered on medical oncology as part of induction therapy with surgery and radiation oncology following in sequence based in part on response to therapy. As treatment has moved away from induction, the ownership of the pathway for addressing these important issues for patient care has become less clear. Today, with human papillomavirus (HPV) biomarker-driven disease now associated with therapeutic titration, the value of chemotherapy and the duration and volume of radiation therapy is under study, especially in patients with selected disease amenable to surgical intervention. Accordingly, the pre-therapy effort that needs to be addressed at the time of diagnosis is often completed by the therapy group taking the initial step in care which would be surgery or radiation therapy as chemotherapy, as a sole service treatment, at diagnosis is rarely considered at this point, excluding advanced cases. Since most patients are less amenable to surgery at presentation, today the initial evaluation and work up is often completed by radiation oncology. These are challenging patients to plan and manage as the sequelae of management directly affects tissues of rapid and partially delayed self-renewal potential and this directly impacts quality of life during therapy. Patients develop the anticipated degree of swallowing discomfort associated with mouth dryness and decreased taste, all of which require attention to detail and often near daily interactions with providers. Radiation oncology evaluates these patients frequently and they are formally seen at least one day per week during their management, therefore radiation oncologists serve as a conduit between disciplines and often are directly responsible for signing orders for nutrition through feeding apparatus and hydration. Often post-therapy follow up care is divided between radiation oncology and otolaryngology. If patients are treated at a geographically distant satellite facility not attended by otolaryngology colleagues, follow up is often performed by radiation oncology with re-referral back to otolaryngology if a possible recurrent lesion is identified or imaging suggests a new issue. It is uncommon today that medical oncology exclusively follows these patients unless they are on study for recurrent disease. With therapeutic titration and decrease in both dose and volume of radiation therapy being evaluated in clinical trials, radiation oncologists will play an increasing important role in the management and follow up care of these patients. It is likely a cohort of patients treated to more limited dose and volume will recur and their management will be difficult balancing constraints for the previous and current treatment plans. Primary management and post-therapy follow up is both challenging and time consuming for the radiation oncologist and the time required to provide optimal care for these often-frail patients cannot not be easily measured by traditional productivity metrics.[6,14,15]

Thoracic/Pulmonary

Thoracic oncology has undergone extraordinary change over the past two decades. Previously considered a disease of habit and environmental exposures, today thoracic oncology has evolved into a disease with multiple molecular biomarkers requiring next generation sequencing to accurately treat patients as the portfolio of actionable mutations continues to expand. Because of delays in obtaining information concerning actionable targets, often these patients arrive in radiation oncology with respiratory or critical organ compromise which requires intervention with radiation as most patients today with advanced disease are not candidates for comprehensive surgical intervention. Radiation oncologists now

initiate critical conversations with patients in the early stages of treatment and often prepare patient for next steps in management pending results from next generation biomarker studies. Although longitudinal management for most patients in the era of targeted therapy has evolved into a shared responsibility between medical and radiation oncology, the initial steps in managing a respiratory event pending completion of staging and plan development are often initially managed through radiation oncology.

Many patients undergo stereotactic therapy for pulmonary nodules and small primary pulmonary malignancies both with and at times without tissue diagnosis. Often these patients are medically compromised and not candidates for surgery or systemic therapy. These patients are often exclusively treated and managed by radiation oncology with follow up imaging managed by radiation oncology in order to not overinterpret parenchymal changes imposed by therapy.

There is increasing interest in more aggressive upfront radiation management of patients with a limited number of metastatic lesions at presentation including the central nervous system, bone, and other soft tissue sites. Radiation oncology is involved in each of these areas including stereotactic and compressed volumetric therapy in association with colleagues in medical oncology as often these patients are treated with concurrent therapy.

Therefore, thoracic therapy has become increasingly complex with respect to management strategies including a significant addition of targeted therapies based on genomic profiles, mutation analyses, and molecular expression products. Although targeted therapies including immunotherapy are managed by colleagues in medical oncology, radiation oncology plays an important role in both the initial phase of management in the acute care setting and longitudinal care of the patient with both limited volume disease and oligometastasis. Radiation oncologists play a strong complimentary role in multidisciplinary care.[16-23]

Gastrointestinal

Although radiation oncology plays a complimentary role with colleagues in both upper and lower gastrointestinal malignancies, there is an increasing role for radiation oncology in the management of hepatocellular carcinoma and cholangiocarcinoma. Often these lesions are not resectable short of liver transplant. Although targeted therapies and systemic therapies are improving, local control of the primary tumor burden remains a challenge and often requires radiation therapy for initial control and serve as a bridge to transplant. Therapy can consist of intra-arterial yittrium-90 (Y-90) or stereotactic body radiation therapy (SBRT). Y-90 can deliver hi radiation dose to selected regions of disease however can also migrate to unintended hepatic segments less well-defined on vascular mapping studies and also impose dose on organs not seen on single-photon emission computed tomography (SPECT) imaging when dose computation is generated on voxel dosimetry software. Stereotactic body radiotherapy (SBRT) can provide security that dose to target is accurate, however motion must be carefully managed as positioning is influenced by respiration. These are patients that require a skilled team of investigators for management including hepato-biliary surgeons, medical and surgical transplant physicians, interventional and nuclear radiology, medical/radiation oncology, and support staff. Radiation oncology and therapeutic application of radiolabeled Y-90 play an important role in providing stability to the clinical situation to determine next steps and feasibility of potential transplant in the future. Each share leadership responsibilities as part of team management in order to optimize strategy for tumor control to bridge patients for next steps in management. Radiation oncology plays a strong complimentary role in esophageal, pancreatic, and colorectal carcinoma supporting multidisciplinary care.[24,25]

Genitourinary-Prostate

Management of patients with primary prostate carcinoma is an area of increasing importance for leadership in radiation oncology as patient outcomes with radiation therapy are excellent. Process improvements including intensity modulation, image guidance, and optical tracking have permitted treatment to be delivered with accuracy and security. Favorable biology and process improvements in treatment execution have provided the opportunity to treat patients with increased daily dose and shorter hypofractionation treatment schedules including protocols with extreme fractionation of as few as 5 treatments. Volume modulated arc therapy permits treatment delivery in a few minutes further ensuring stability in daily positioning and motion management. With these process improvements moving into routine practice, the volume of patients seeking radiation therapy as a primary treatment option for care is

significantly increasing and departments will be committing more full-time employees (FTE) to this program. This also means that radiation oncology will own the follow up and after care of these patients as well as reporting outcomes in a fair and balanced manner. In selected circumstances radiation oncology and surgery have been responsible for the application of hormone therapy for patients with less favorable features including those with intermediate and high-risk disease. There has been a significant increase in the number of preparations in the application of hormone therapy. Each will need to be tested against each other for efficacy, non-inferiority, and toxicity as each will likely be an important component for combined modality therapy. Therefore, in a protocol setting, often medical oncology and radiation oncology may share responsibility for primary management and application of hormonal therapy including follow up care. In a non-protocol setting, often the radiation oncologist now provides the majority of follow up care including assessment of normal tissue function and tumor control. Although brachytherapy genitourinary experts have succeeded in this role for more than a decade, the leadership role of radiation oncology in this area of patient care is rapidly moving into enterprise function including experts in compressed and accelerated fractionation. As outcomes continue to improve and patient volume increases with treatment courses becoming further compressed, this aspect of radiation oncology is beginning to mimic surgery without the operating room and anesthesia. The paradigm shift requires the radiation oncologist to be fluent in applied imaging including the integration of MRI and computed tomography (CT) for target definition and applying dose gradients as appropriate to normal tissue structures.

With medical oncology colleagues, there is increasing responsibility of radiation oncology to be aggressive in the management of patients with oligometastatic disease. This is a shared responsibility between providers and radiation oncologists need to choose a strategy for care of limited volume metastatic disease with a balance of objectives including limitation of radiation dose to normal tissue coupled with disease control in the metastatic site. Although bone was considered the primary site of metastatic disease in the past, today metastatic disease involves multiple soft tissues well identified on modern metabolic imaging including recurrence in the prostate and lymph node regions.[26]

Theranostics

Theranostics is maturing as an important imaging tool for oncology patient care management and potentially an important therapeutic tool using radiation therapy as a systemic treatment strategy. There are an increasing number of compounds being developed linking biomarker imaging constructs and subsequently using the compound on a radiolabeled manner to treat patients with radiation therapy being selectively delivered to sites associated with the biomarker. These hold promise in the treatment of multiple disease sites including metastatic prostate cancer, neuroendocrine carcinoma, and others including neuroblastoma. The history of radiopharmacy dates to I 131 therapy for thyroid carcinoma. Unlike modern radiation oncology, strategies for treatment were based on the potential dose delivered and not the dose absorbed, due in part to historical limitations in having validated predictive models for assessing dose absorbed. This was also problematic when Radium 223 was established as therapy for metastatic prostate carcinoma. The breakdown product, strontium, would have affinity for bone, therefore would provide indirect and bystander treatment to metastatic lesions in the bone. This treatment had limitations as clinical care providers now see significant metastatic tumor burden in soft tissue which would not be influenced by infusion of radium. However, Radium 223 provided a significant resource in the development of voxel dosimetry of measuring absorbed dose to both tumor and normal tissue targets with radiopharmacy compounds. This is a significant step forward as we are now in a position to understand the radiobiology of normal tissue injury and tumor control with these compounds. With biomarker diversity and asymmetric uptake within a target based in part secondary to biomarker distribution, we can now understand tumor control with dose and what may be needed to supplement dose to target with radiosurgery.

The ABR developed the term authorized user in order to provide for trained individuals in radiology, nuclear medicine, and radiation oncology to administer diagnostic and therapeutic compounds and isotopes for both imaging and therapy. There is injury to normal tissue with the use of radiation therapy either through teletherapy, brachytherapy, or systemic radiation therapy. Although colleagues in imaging have infrastructure to administer and infuse systemic radiotherapy, radiation oncologists are the primary caregivers in understanding injury and not to exceed thresholds

for tolerance. This is not in the purview of medical oncology who often will perceive systemic radiotherapy as a drug without understanding the downstream consequence of radiation injury. Patients receiving systemic radiotherapy can have co-existing deficiencies in normal tissue function. When systemic radiotherapy is superimposed on a compromised background of normal tissue function, dose volume tolerance limits are not known as the clinical trials were only performed on patients who met protocol criteria. When one looks at a prostate-specific membrane antigen (PSMA) scan, there is uptake in multiple organs including lacrimal glands, parotids glands, liver, kidney, and bladder. These organs will receive dose and the dose will be full volume distribution over a protracted period of time and not limited to portion of the normal tissue volume which can be tailored with teletherapy. When one administers radiation therapy, the written directives require establishing dose volume constraints to targets. Prior to the development of voxel dosimetry, this could not be successfully anticipated with radiopharmacy. Since radiopharmacy is most often fractionated, imaging tools and dosimetric calculations can be developed to calculate dose and optimize dose volume constraints. Moving forward, medical oncology, nuclear medicine, interventional radiology, and radiation oncology will each play an important role in the development of an institutional program in theranostics. Successful clinical trials in this important area will also require contributions from the strengths of each discipline.[27,28]

Complimentary Multidisciplinary Roles

In several disease areas radiation oncology plays an integral role with medical and surgical oncology partners. Tri-modality care with varied points of emphasis in sequence between disciplines are considered standard of care in many disease sites including breast, esophagogastric, colorectal, anal, bone and soft tissue sarcoma, gynecology, dermatology, bladder/renal, and pediatrics. Radiation oncologists contribute to the development of the care plan and interact with the patient and family at appropriate time points during treatment and follow the patient post therapy to assist in survivorship care. Often the care plan generated in radiation oncology is important in the evaluation of the patient for survivorship planning. For example, many normal tissues are unintentional targets for therapy. The heart and cardiac segments can receive indirect dose from thoracic radiotherapy including lung, esophageal, and breast radiotherapy. Although modern technology can provide segments of conformal avoidance for structures, the esophagus abuts the left atrium, therefore segmental dose can be unintentionally applied to the electrical conduction system. Patients with left sided breast carcinoma can now be treated with optical tracking and breath hold techniques to limit and nearly eliminate cardiac dose, however previous patients treated without these technologies did receive measurable dose to the left ventricle myocardium. Lung cancer patients can have unintentionally significant cardiac subsegments in the therapy fields. Radiation oncologists need to be active participants in plan development, plan execution, and follow up care to support all aspects of patient care including managing expectations post therapy. This helps ensure that the multidisciplinary providers remain in communication with each other and provides a consistent message to the patient and primary care physician. This will support the care of the patient as part of survivorship models moving forward.[29-35]

The Future Radiation Oncologist

Radiation oncology has become a different specialty since the first generation of trainees began practice more than 50 years ago. Managing patient care had fewer administrative layers and expectations of both the physicians and patients were different. In early iterations of patient care, success was measured by tumor control as fewer than 50% of patients were treated with curative expectations in radiation oncology. Today, tumor control is far improved and often the expected outcome. Success is now measured not only by tumor control but also by normal tissue tolerance. Today the majority of patients are treated with curative intent, hence the heightened expectations for outcome. Today treatment planning is highly sophisticated, and volume driven with multiple anatomic and metabolic image datasets in both three and four dimensions required for target volume definition. Early radiation oncologists completed the task of simulation during the time spent in the fluoroscopic simulator. Today the primary work of the physician begins when the patient leaves the simulator as datasets need to be fused into planning CT and/or MR planning images to begin contouring targets for therapy. Treatment is delivered with volume modulated arcs with full image guidance and optical tracking for stability in both treatment set up and reproducibility. The responsibility of the radiation oncologist in the department is significant as onsite management during the treatment schedule is spontaneous, required by regulatory agencies, and essential to

mission for safety of workflow. During the same time open lines of communication are required to keep colleagues and patients apprised of their status and facilitate. There are multiple schedules within the clinical department including the new patient schedule, follow-up schedule, on-treatment schedule, and the daily treatment schedule. The multiple schedules overlap at varied timepoints during the day and often unintentionally conflict with workflow for physicians. Nevertheless, time must be managed, or else time will manage the radiation oncologist. Often this is how careers derail and physicians become less productive relying too much on how they were trained as opposed to embracing change in the field which requires education and willingness to acknowledge changes in workflow process. Many in our field have used adoption of changes as contribution towards academic effort including advancing artificial intelligence technologies in the workplace and research environment. The modern radiation oncologist has to play a hybrid role in understanding and improving technology while moving our academic mission forward with rapidly evolving data. The skill set of the modern radiation oncologist requires a keen knowledge of functional anatomy, radiology, physics, radiobiology, radiopharmacy, normal tissue tolerance and the impact of systemic therapy on normal tissue including moving these concepts into translational and basic science. Large datasets, similar to the architecture provided at the Imaging and Radiation Oncology Core (IROC) and The Cancer Imaging Archive (TCIA) will be important to move our translational science forward at an institutional level. The informatics architecture for TCIA can be re-purposed for use by individual institutions for onsite management of institutional data. The architecture permits facile integration of pathomic, radiomic, radiation oncology, and clinical datasets into a single platform with innumerable software tools to perform quantitative research in all disease sites including research in artificial intelligence. IROC contributes clinical trial information including complete and outcome imaging and radiation oncology objects to TCIA for secondary research objectives. To date, the informatics infrastructure at TCIA has supported more than 1,200 publications with more than 2,000 queries per month of the data set. Information similar to TCIA will be required by institutions for generation of publications including emphasis on clinical translational process improvements. Data housed in this format can be used by all solid and liquid disease sites for secondary research. This requires that departments maintain a data management center for all patients seen and evaluated for radiation therapy. The record required by regulatory agencies for certification in radiation oncology must have similar information. There are numerous software tools available that can transfer this information into a single database and apply query tools associated with TCIA and other groups for research. This serves to enhance engagement of faculty, promotes career development, and supports retention of faculty thought valuable to mission. This also supports career development of medical and allied health students and supports integration of all staff into process improvements processes with radiation oncology faculty serving as mentors. Radiation oncologists can lead this effort in the development of modern data management as pathology, imaging, surgical/medical data are essential to the development of a radiation therapy treatment plan. Housing a data management division in the department of radiation oncology using current software tools available in radiation oncology treatment planning systems will further support leadership positions in cancer programs for radiation oncology.

The modern radiation oncologist will be both a clinician and a scientist promoting initiatives to move our field forward. Survivorship models and predictive indices for injury both anticipated and unanticipated will evolve from scientific models we generate from large datasets. We are and will remain at the forefront of patient care. Because we work with all science departments and clinical divisions involved in cancer care, we are poised to become clinical and science leaders in the oncology community. This is a step forward for our discipline however it comes with the responsibility of accepting the elevated expectations of our performance. As we take more responsibility in the care of the oncology patient, this becomes our responsibility to make certain the cycle of care is met, communication is complete, and our science moves forward. Our time has become to become leaders in the field of oncology.[36-44]

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