Undergraduate medical education and radiation oncology: Current concerns and effective initiatives

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While radiation oncology (RO) has become an increasingly popular and competitive specialty over the past decade, the proportion of medical graduates entering RO residencies may be leveling off, or even declining.[1] At the same time, cancer remains one of the leading causes of death in the United States and worldwide,[2] fueling the demand for oncologists, including radiation oncologists. Thus, there is a critical role for the integration of RO teaching in medical school education, with the goal of continuing to attract students to the specialty. However, the majority of medical schools lack formal teaching of this discipline, and many students receive little exposure to the field.[3] The question of how to improve integration of RO into medical education remains up for debate. This article will examine limitations to, and the various methods of, implementing radiation oncology education in medical school curricula.

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Concerns, Challenges in Radiation Oncology Medical School Education

While oncology is a common choice of specialty for medical graduates, oncology education at many medical schools remains relatively fragmented and underemphasized compared with other fields.[4-6] The multidisciplinary nature of oncology and its span across different organ systems makes its integration into medical school curricula complex and sometimes disjointed. As a result, there is significant variability between schools in the way oncology and its subspecialties, including RO, are taught,[5] and students may lack confidence in their overall knowledge regarding cancer care despite having learned about its various components.[7] Moreover, students have reported less confidence with oncologic treatment compared to the basic science and diagnosis of cancer,[4,6] indicating a need for greater emphasis on multidisciplinary clinical management in cancer education during medical school.

Compared with other oncologic subspecialties, less is taught about radiation oncology in medical school;[8] thus, many students receive little meaningful exposure to this smaller and more specialized field. The inadequacies in radiation oncology education during medical school have been well described.[8] For example, a 2016 survey analysis of 105 medical students at two U.S. medical schools found that while medical students report increased comfort from MS1 to MS4 with medical and surgical oncology, the same trend was not found in radiation oncology.[7] Moreover, upper-year medical students were found to have the least experience in RO and survivorship care compared with other aspects of oncology.[7] Another analysis of students at a single institution who participated in an oncology education initiative found that while the majority of students considered oncology and RO to be important topics in medical education, most reported that the clinical years provided insufficient exposure to these topics.[9] While misconceptions about radiation oncology have been shown to decrease with increased level of training, from MS1 to MS4, medical students still have misguided notions about different aspects of RO, including those about RO as a profession, the appropriateness of radiation therapy in clinical contexts, and radiation toxicity.[10] Many schools lack requirements to participate in nonsurgical oncology rotations during the clinical curriculum, while others do not require any oncology-focused clerkship.[4,6] As a result, the majority of students who

participate in RO electives are those who plan to apply for an RO residency, and most students entering other fields have little exposure.[4,9]

Several factors are thought to contribute to the lack of RO education in medical curricula. One noteworthy contributor is likely an imbalance in the types of specialists providing the majority of oncology education.[6] Some evidence suggests that a large portion of oncology teaching during the preclinical years is by medical oncologists, pathologists, and PhDs, while most teaching during the clinical years is provided by surgical and medical oncologists. Radiation oncologists, in contrast, have been shown to be significantly less involved in medical education during both the preclinical and clinical years compared with other oncologic subspecialists.[6,11] Moreover, being a particularly small and specialized field, RO is often considered a "niche" specialty and, thus, is given less importance and time compared with other more general disciplines in already jam-packed medical school curricula.[9] The smaller number of radiation oncologists compared with medical and surgical oncologists is likely a contributing factor as well.

It is important to note that issues of diversity and inclusion render exposure to radiation oncology critical in regard to subsets of the medical provider population under-represented in the field. Specifically, reports have shown that radiation oncology lacks diversity in its representation of women and certain minority groups at all levels of training.[12,13] Female representation in academic radiation oncology specifically may lag behind other oncologic subspecialties, with the number of female trainees declining in recent years.[14] Moreover, while representation of women and under-represented minorities (URMs) in medical school has improved over the past several years, their representation in RO has only slightly increased over time.[15] Several factors are thought to contribute to this trend, including inadequate and/or late exposure to radiation oncology as well as fewer female and URM role models in the field, owing to the lack of representation of these two groups in RO.[14,16] Therefore, greater exposure to RO during medical school is needed to help create an RO provider population that accurately represents its patient population. Initiatives to ensure that under-represented groups in particular have access to meaningful exposure to and experience in radiation oncology can help bridge this disparity. The American Society for Radiation Oncology (ASTRO), for example, offers a Minority Summer Fellowship Award, which aims to provide URM students with early research and clinical experiences in RO and mentorship opportunities with members of ASTRO's Committee on Health Equity, Diversity and Inclusion.[17] Additionally, early exposure through electives and student interest groups, particularly at medical schools with a greater percentage of URM students, as well as greater effort to provide mentorship to female and URM students potentially interested in RO, can help address this problem.[16]

There are several methods of integrating radiation oncology teaching into medical school curricula, not only in terms of teaching format but also with regard to timing in the curriculum and subject matter covered. The principles of radiation oncology can be taught during the preclinical years (M1-M2) of medical school, through different learning formats including lectures and workshops. Radiation oncology can also be introduced during the clinical year (M3) through optional or mandatory clerkships with or without didactic components. Subject matter covered in preclinical teachings and clinical RO electives can include radiobiology, medical physics, treatment planning, patient treatment process, and patient follow-up. Students can also gain informal exposure to radiation oncology through research—either during the summer after M1 or through a year-long research experience in RO, typically after M3—and other extracurricular activities. These options for exposing medical students to the field of radiation oncology will be explored throughout this article.

Radiation Oncology and the Clinical Clerkship

One of the most established and effective methods for introducing medical students to radiation oncology is through a clerkship during the clinical year. Interventions to improve exposure to RO during the core clerkships have been described in the literature, with RO elective rotations significantly improving knowledge and understanding in several aspects of the specialty and found to be highly useful by participants.[18] Different models of the RO clerkship exist—including those with didactics, those lacking a didactic component, and those integrated into mandatory pre-existing clerkships—with varying degrees of efficacy, as will be discussed.

The structure of the clinical clerkship in RO is critical to its effectiveness. While clinical clerkships can serve as a valuable method of increasing student understanding of RO, many clerkship structures have had limitations—namely, a lack of a formal didactic curriculum to accompany clinical activities.[7,19] A 2012 survey analysis of 35 MS4s applying for radiation oncology residency found that of the 97 clerkship experiences evaluated, only 23% included hands-on didactic sessions and only 35% included lectures specifically for MS4s, while 52% (50) had no formal lecture, case discussion, or hands-on didactic session.[7] At the same time, the participants ranked didactic hands-on sessions in contouring/planning and lectures on treatment planning, radiobiology, physics, and evidence-based medicine to be among the educational activities of most importance in a

radiation oncology clerkship curriculum. Similarly, a survey analysis including responses from 70 applicants to a single radiation oncology residency program between 2012 and 2013 found that only 27% of applicants had completed at least one clerkship with an appropriate-level didactic component.[19] Given that little is taught about radiation therapy during the preclinical years of medical school and that it remains one of the lesser-known specialties, the need for a structured didactic curriculum to provide foundational information during RO clinical rotations is significant. Moreover, participation in radiation oncology clerkships that include a formal didactic component has been significantly correlated with greater confidence in preparation for RO residency.[19] Thus, recent research has focused on improving the quality and structure of education and, in particular, that of didactics, during these clinical clerkships.

Radiation oncology clinical clerkship models that include didactic components are more effective and can teach medical students aspects of RO that might otherwise be difficult to learn without a formal lecture component, such as medical physics and radiobiology. Programs that have introduced didactics into their RO rotations have shown success. For example, Golden et al reported on a formal didactic curriculum designed in 2012 to accompany a 4-week radiation oncology clerkship.[20] While the curriculum began as a bi-institutional intervention, it has now grown into a multi-institutional cooperative. It consists of a series of three 1-hour lectures on topics including the foundations and history of radiation oncology; radiobiology and radiation physics; and simulation, treatment planning, and emergencies in radiation.[21] Additionally, the course includes a 1-hour hands-on dosimetry workshop in which students use a guide to delineate a target, select beams, and optimize beam parameters. The pilot curriculum was a success, rated as extremely useful along all curriculum components by the 18 participating students. Moreover, students reported that the clerkship curriculum helped them feel more confident in their choice of specialty and more prepared for RO residency. Consequently, the curriculum was expanded to 11 institutions as a research cooperative in 2013 with 94 participating students, again with similarly successful results based on qualitative student feedback.[21] Moreover, the benefits of this didactic clerkship curriculum have been demonstrated in comparison to radiation oncology clerkships lacking structured curricula through a survey analysis, which found participation in a clerkship curriculum site to be significantly correlated with higher confidence in future ability as an RO resident.[22] In addition, the didactic curriculum has demonstrated the ability to produce lasting objective improvements in knowledge about radiation oncology in participants through pre- and post-test assessments.[23] The radiation oncology clerkship developed at Jefferson Medical College in 2010 includes two small-group standardized didactic sessions per week on various topics within radiation, inpatient and outpatient consults, as well as case-based presentations by the students. Participating students also observe simulation, treatment planning, dosimetry, and radiation therapy technologists. The rotation has been found to significantly improve objective knowledge in RO and was well-rated in usefulness by participating students.[11]

Other interventions to improve radiation oncology education during the clinical years have been explored, including those that introduce students to the specialty outside of a standard radiation oncology clerkship. For example, Singh et al have reported on the efficacy of a multidisciplinary oncology education initiative integrated into the required radiology clerkship at Boston University School of Medicine.[9] The initiative included didactics on cancer diagnosis and management, and concepts in radiation oncology, as well as optional student participation in RO consultations and treatment planning sessions. Most students found that the radiology rotation was an appropriate time to learn about oncology and radiation oncology and reported that the experience motivated them to learn further about oncology and RO. Thirty-two percent of the students also decided to pursue advanced on-site training in RO after this educational initiative. Moreover, the fact that most students reported knowing little to nothing about radiation therapy before the course highlights the value of incorporating RO teaching into a required clerkship or other mandatory curricular component so that all students have a baseline level of exposure. The initiative has also been shown to significantly improve medical students' knowledge about RO, including treatment, brachytherapy, and side effects, through pre- and post-test examinations, indicating the efficacy and feasibility of integrating radiation oncology teaching into a pre-existing clerkship.[24,25] Such a model may provide the greatest benefit by ensuring that all students, regardless of professional interests, are exposed to some degree to this lesser known specialty.

Although substantial progress has and continues to be made in improving the structure of radiation oncology clinical clerkships, shortcomings remain. For example, evidence suggests significant grade inflation in RO clerkships compared with other clinical rotations. In an analysis of applicants to a single radiation oncology residency program in 2011 and 2012, 80% of the 167 who participated in a graded radiation clerkship received the highest possible grade. Moreover, compared to clerkship grades in medicine, surgery, pediatrics, and obstetrics/gynecology, grades in radiation oncology were significantly higher ($p < 0.001$), resulting in more challenging evaluation of applicants and missed opportunities for meaningful feedback. Additionally, the timing of didactic components within RO clerkships may be improved

to ensure an adequate foundation of knowledge before students progress through the clerkship.[21]

RO clinical clerkships can provide students with valuable clinical experience in treatment planning, dosimetry, and patient care, as well as a greater understanding of radiation fundamentals including medical physics and radiobiology through didactic components. However, a major disadvantage of using this model exclusively to provide RO education in medical school is providing students with late exposure to the specialty. Early integration of RO teaching during medical school, such as in the preclinical curriculum, can overcome this challenge, as will be discussed in the next section.

Preclinical Exposure to Radiation Oncology

In addition to clinical clerkships, radiation oncology can be integrated into the preclinical curriculum through lectures, workshops, and other methods of instruction. Importantly, students could benefit from early introduction to RO to better inform their career path and shape their trajectory throughout medical school. Since RO residency programs desire significant research experience, particularly within the field, exposure to the specialty during the preclinical years may benefit students by providing them with more time to engage in RO-specific research as well as other RO and oncology-oriented activities.

The oncology unit may provide an opportune time for introducing medical students to RO in the preclinical curriculum. Formal discussion of RO at this point may better prepare students for RO clerkships and rotations in the later part of medical school and can help inform students' decisions to participate in such clerkships. Given its multidisciplinary and inter-disciplinary nature, there are different methods to integrate oncology teaching during the preclinical years. For example,oncology teaching can be interspersed throughout system-based modules or taught as a single block.[26] Agarwal et al found success with a dedicated core oncology block during MS2.[27] The course was led by a radiation oncologist course director, and students reported that it helped them understand cancer therapy and prepared them for oncology-focused clinical electives, including electives in RO. Many believe the block format provides more cohesive and comprehensive education in oncology compared with the integrated method. Moreover, introduction to the principles of radiation oncology—including radiation therapy fundamentals, treatment planning, radiobiology, and radiation physics—may be integrated seamlessly during this dedicated core oncology block structure, and can provide context to subsequent lectures on site-specific treatments for the remainder of the preclinical curriculum. However, both approaches along with others are utilized, and there is currently no standard for how to structure oncology curricula during the preclinical years.[5,26]

Moreover, medical school curricula have evolved to include several innovative learning formats beyond standard didactics. There has been a shift toward greater implementation of small group, workshop, team-based, case-based, and experiential learning methods over traditional lectures, with a greater emphasis on the learner rather than teacher.[5] Thus, several methods can be utilized to incorporate radiation oncology teachings into the preclinical curriculum. Duke University School of Medicine, for example, developed an onco-anatomy course in 2005 open to medical students through the department of radiation oncology.[28] The course focuses on providing anatomy teaching relevant to RO, including the correlation between anatomic tumor location and symptoms, anatomical treatment considerations, and anatomic assessment of tumor spread. The course utilized different learning methods including case-based presentations, didactics, and cadaver demonstrations, and received favorable reviews by participants. Similarly, an onco-anatomy elective supervised by the radiation oncology department was developed at University of Rochester for MS1s and MS2s, with an emphasis on radiologic anatomy on computed tomography (CT) and magnetic resonance imaging (MRI).[29] The elective used several learning formats—including group discussions, small group sessions, anatomy reviews, and didactic lectures—providing students with a more nuanced and comprehensive understanding of anatomy relevant to radiation oncology. Employing multiple learning formats in the teaching of radiation oncology can actively engage students and help these learners obtain and synthesize information more dynamically and comprehensively.

Beyond Curriculum Exposure and Implications for Residency

Several opportunities extend beyond those in the standard medical school curriculum for students to gain meaningful experience in radiation oncology, including research, health policy engagements, and dual-degree programs. Moreover, the expectation for students applying to radiation residency programs is that they have engaged in some, if not several, of these other opportunities. Research experience is particularly important in RO, with radiation residency applicants having a significantly higher mean number of publications, posters, and research experiences compared with applicants to other specialties.[30] Effective mentorship is a critical contributor to research productivity, and its value in supporting the development of successful radiation oncology applicants has been documented.[31] In addition to research opportunities with radiation oncologists at one's own institution, several national research programs provide medical students with research experience in radiation, many of which students participate in during the summer after MS.[30]

Year-long programs can provide a more in-depth experience with greater opportunity to produce and publish meaningful research in the field of RO. Moreover, there are opportunities for students to engage in health policy work relevant to the practice of radiation oncology. Dual degrees also provide students the opportunity to study oncology, or RO more specifically, through a variety of disciplinary lenses, and several students matching into RO have pursued a second degree.[30]

Conclusion

Radiation oncology is poorly integrated into the curricula at many medical schools. Thus, students may fail to gain adequate exposure to the field. Cancer remains one of the leading causes of death, making the continued attraction of future radiation oncologists critical. Implementation of RO education into medical school curricula can take several forms, including introduction during both the clinical and preclinical years. Moreover, RO teaching can be integrated into existing components of medical curricula, such as established clerkships and through multi- and cross-disciplinary education initiatives. Ongoing evaluation of the current methods used to teach radiation oncology in medical school is needed to inform future educational interventions.

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