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EDUCATION AND TRAINING

The AAPM/ASTRO 2023 Core Physics Curriculum for Radiation Oncology Residents

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Purpose: The American Association of Physicists in Medicine Radiation Oncology Medical Physics Education Subcommittee (ROMPES) has updated the radiation oncology physics core curriculum for medical residents in the radiation oncology specialty.

Methods and Materials: Thirteen physicists from the United States and Canada involved in radiation oncology resident education were recruited to ROMPES. The group included doctorates and master's of physicists with a range of clinical or academic roles. Radiation oncology physician and resident representatives were also consulted in the development of this curriculum. In addition to modernizing the material to include new technology, the updated curriculum is consistent with the format of the American Board of Radiology Physics Study Guide Working Group to promote concordance between current resident educational guidelines and examination preparation guidelines.

Results: The revised core curriculum recommends 56 hours of didactic education like the 2015 curriculum but was restructured to provide resident education that facilitates best clinical practice and scientific advancement in radiation oncology. The reference list, glossary, and practical modules were reviewed and updated to include recent literature and clinical practice examples.

Conclusions: ROMPES has updated the core physics curriculum for radiation oncology residents. In addition to providing a comprehensive curriculum to promote best practice for radiation oncology practitioners, the updated curriculum aligns with recommendations from the American Board of Radiology Physics Study Guide Working Group. New technology has been integrated into the curriculum. The updated curriculum provides a framework to appropriately cover the educational topics for radiation oncology residents in preparation for their subsequent career development. © 2023 Elsevier Inc. All rights reserved.

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Introduction

Radiation physics is a core component of radiation oncology and an essential didactic component of medical residency programs within the field. A comprehensive curriculum ensures practitioners are well versed in appropriate topics through consistent inclusion of subject matter and clear expectations of teaching intensity. In the early 2000s, the American Association of Physicists in Medicine (AAPM), the Radiological Society of North America (RSNA), and the American Society for Radiation Oncology (ASTRO) devoted resources to improving and standardizing the quality of physics education for physicians. The initial effort to establish a curriculum in radiation oncology physics began in 2002 with the creation of the Committee on Physics Teaching to Medical Residents by ASTRO.[1] In addition to the development of a comprehensive core curriculum, a second goal was to periodically update the curriculum to include new technology and techniques. The first curriculum was published in 2004[1] with subsequent revisions in 2007,[2] 2010,[3] and 2015.[4] The most recent update was produced by the ASTRO Physics Core Curriculum Subcommittee (PCCSC), founded in 2009. The PCCSC focused on "making recommendations for physics curriculum based on resident career needs, communicate with the American Board of Radiology (ABR) so that they may use these recommendations to update examinations, and move to centralized web-based teaching aids." The 2015 update incorporated modern technology and techniques while still preserving the fundamental physics components.[4]

In addition to updating the curriculum, it was proposed to transition physics education to web-based modules to allow for more widespread distribution of material. With similar goals, the Radiological Society of North America developed the first web-based modules for radiology residents beginning in 2010. A comprehensive set of online modules covering the basic physics domains was available by 2014. To promote the same educational experience for radiation oncology residents, AAPM formed its own education-focused subcommittee, the Radiation Oncology Medical Physics Education Subcommittee (ROMPES) in 2013. ROMPES was given 4 charges: (1) establish goals for educational resources, including web-based educational modules for residents and practicing physicians, (2) coordinate and pursue potential support with educationally oriented diagnostic radiology organizations or companies with an interest in supporting medical physics education, (3) develop standard templates for education resources, including educational modules or programs, and (4) explore timely resource development and physician collaboration in such resources.

With these charges in mind, ROMPES developed a series of 5 pilot radiation oncology physics modules. The module topics mirrored the existing core curriculum and were 5 to 10 minutes long, developed and reviewed by physicists. Between 2014 and 2018, 22 more of the modules were created covering 5 domains of the core curriculum. In 2017, with an understanding of the effort required to create modules, ROMPES requested financial support from the AAPM and ASTRO to continue module development. Before support was approved, the 27 modules were posted on a site hosted by AAPM (https://www.aapm.org/org/structure/committee/infogroup.asp?view=1648) and the usage was tracked for 1 year. With mixed feedback, limited site traffic, and no commitment for financial support, AAPM Education Council voted to discontinue the development of further modules. A major limitation to this site was access limited to AAPM members. The 5 pilot modules were also posted on the ASTRO website (https://academy.astro.org/content/introductory-physics-modules#group-tabs-node-course-default5) with access granted to ASTRO members-in-training. Recently, the modules have been added to the ARRO website, as well (https://www.astro.org/Affiliate/ARRO/Resident-Resources/Educational-Resources/Physics-and-Biology-Resources/Radiation-Physics).

Around the same time that support for the module initiative waned, 2 events occurred. First, the passing rate for the 2018 ABR Radiation Oncology Physics qualifying examination was significantly lower than for previous years, raising concerns over examinee preparation and examination difficulty and scoring.[5,6] To address this, ASTRO convened a working group that recommended aligning the ABR study guide with the current ASTRO physics core curriculum to coordinate the structure and organization between the guide for examination preparation and the guide for resident education. Although the 2015 core curriculum provided a concordance between the content covered by each, the ASTRO working group recommended that they share an identical structure.[4,6] The second event was the sunsetting of the ASTRO PCCSC in 2019. Together, these events prompted an ABR stakeholder review of the study guide and the initiation of a working group to review the guide annually to ensure an accurate reflection of current educational guidelines.

To assure the continued development of the radiation oncology physics core curriculum after the sunset of the PCCSC, the AAPM identified ROMPES as the ideal group to update the core curriculum. In 2020, a request was made to AAPM to amend the ROMPES charges to the following: "To establish liaisons with organizations in the radiation oncology community who are interested in supporting new methods of radiation oncology Resident training. The specific charges are to: develop, maintain, and publish a medical physics curriculum recommended by the AAPM for radiation oncology residents; to pursue and facilitate collaboration with relevant stakeholder organizations on curriculum content; to review the ABR Study Guide for Radiation Oncology Physics annually and provide feedback to the ABR via representation on the ABR Physics Study Guide Working Group, which will be appointed by the committee on an annual basis according to the guidelines established by the ABR." This charge was officially approved in 2021.

Almost 8 years have passed since the last update of the physics core curriculum, marking the longest break between updates since the inception of a core curriculum in 2002.

During this time, there have been substantial advances in technology and clinical innovation, we saw a drop in the passing rate on the ABR examination in 2018 sparking concerns over examinee preparation,[6] and a global pandemic has reshaped the way we teach and learn as a society.[7] With these issues in mind, this report presents an update to the physics core curriculum for radiation oncology residents.

Methods and Materials

Thirteen medical physicists from the United States and Canada were recruited to ROMPES, including physicists in clinical and academic roles with doctorate and master's degrees. Radiation oncology physician and resident representation were also included. All participating physicists and physicians had an educational role in their respective departments.

In addition to generating a comprehensive curriculum to ensure the best practice for radiation oncology practitioners, a major goal of this update was to promote concordance between the guides for resident education and examination preparation. On the examination preparation side, the current guide for ABR Radiation Oncology Medical Physics examination can be found online (https://www.theabr.org/radiation-oncology/initial-certification/the-qualifying-exam/studying-for-the-exam/medical-physics-radiation-oncology).[8] The guide contains educational domains and weighting (Table 1). These domains are reviewed by the ABR Physics Study Guide Working Group on an annual basis and are used to generate the annual examination contents.

On the resident education side, feedback was obtained from each member of ROMPES, and it was agreed that the weightings recommended by the ABR working group appropriately represented their recommended curriculum, as well. The first step to generate the new curriculum was to distribute the hours devoted to each educational domain into the chosen weighting ranges. The details of each domain were discussed and approved by all ROMPES members and the physician members in a series of virtual meetings. The final step was to review and update the appendices, including the references, glossary, and practical modules.

Table 1 Current educational domains and weighting for the American Board of Radiology study guide for medical physics for radiation oncology[8]

2022 Educational domains	
Domain	**Weighting (%)**
I. Basic physics	11-13
II. Radiation measurements	9-11
III. Treatment planning	19-21
IV. Imaging modalities and applications in radiation therapy	16-18
V. Brachytherapy	12-14
VI. Advanced treatment planning and special procedures	15-17
VII. Safety, quality assurance, and radiation protection	11-13

Results

The revised 2023 core curriculum recommends 56 hours of didactic education as in the 2015 curriculum. Table 2 outlines the changes to the curriculum structure. Detailed subsections for each domain can be found in Appendix E1. There were several major changes from the 2015 core curriculum. The length of the orientation was reduced from 4 hours to 1 hour. The radiation physics lectures do not always occur at the very beginning of a residency, and topics with a focus on the basic knowledge a resident would need entering a clinic should be covered during the initial resident orientation. These topics are listed in Appendix E1 and could also be supplemented by the modules found in the 2015 core curriculum Appendix E4 and E5,[4] as noted. The hour orientation in this curriculum is designed as refresher to answer any questions residents have before the lectures begin. Minimal changes were made to the basic physics section other than a reduction in didactic hours to allow for additional focus on clinical applications. This change was made based on personal discussions with residents from different departments and following the change made by the ABR Physics Study Guide Working Group. To consolidate treatment planning topics, intensity modulated radiation therapy was moved from advanced treatment planning as this is now a common planning technique in most clinics. The subsection covering prescribing, reporting, and evaluating radiation therapy plans was also moved to an earlier domain to align with the other treatment planning topics.

The simulation and treatment verification subsection was modified to include motion management in addition to the existing topics. This subsection was further broken down to cover image-based treatment verification with both x-ray and non-x-ray producing modalities. The 4-dimensional computed tomography topic was moved to the simulation and treatment verification section along with a section on intrafractional imaging to include real-time imaging modalities. The section on informatics was reduced and moved into the imaging section. Brachytherapy was restructured to align with the clinical workflow and now includes brachytherapy quality assurance (QA), which was moved from the general QA section.

Advanced treatment planning and special procedures was divided into 3 subsections: special procedures, particle therapy, and stereotactic radiosurgery/stereotactic body radiation therapy. Adaptive radiation therapy was added as a subsection under special treatment procedures. There were minimal changes made to the radiation safety and QA sections. Finally, the reference list (Appendix E2) was reviewed and updated to include more recent literature and the glossary (Appendix E3) was reviewed and updated.

Table 2 Structure changes in the 2015 and 2023 core curriculum

2015*			2023		
Chapter	Title	Hours	Chapter	Title	Hours
	Orientation	4		Orientation	1
1	Fundamental physics	1	1	Fundamental physics	1
2	Atomic and nuclear structure	2	2	Atomic and nuclear structure	1
3	Production of kilovoltage x-ray beams	2	3	Production of kilovoltage x-ray beams	1
4	Production of megavoltage x-ray beams	3	4	Production of megavoltage x-ray beams	3
5	Radiation interactions	3	5	Radiation interactions	2
6	Radiation quantities and units	1	6	Radiation quantities and units	1
7	Radiation measurement and calibration	3	7	Radiation measurement and calibration	4
8	Photon beam characteristics and dosimetry	7	8	Photon beam characteristics and dosimetry	5
9	Electron beam characteristics and dosimetry	2	9	Electron beam characteristics and dosimetry	2
10	Imaging fundamentals	4	10	Intensity modulated radiation therapy	3
11	Simulation and treatment verification	2	11	Prescribing, reporting, and evaluating radiotherapy plans	1
12	Informatics	1	12	Imaging fundamentals	5
13	Intensity modulated radiation therapy	3	13	Simulation, motion management, and treatment verification	4
14	Prescribing, reporting and evaluating radiation therapy treatment plans	1	14	Clinical brachytherapy	6
15	Special procedures	2	15	Brachytherapy QA	1
16	Brachytherapy	6	16	Advanced treatment planning and special procedures	3
17	Quality Assurance	2	17	Particle therapy	3
18	Radiation protection and shielding	2	18	Stereotactic radiosurgery/stereotactic body therapy	3
19	Safety and incidents	2	19	Quality assurance in Radiation Oncology	2
20	Particle therapy	2	20	Radiation protection and shielding	2
21	Stereotactic radiosurgery/stereotactic body radiation therapy	1	21	Safety and incidents	2
22	Research and development in Radiation Oncology Physics (optional)	1			

* Burmeister J, Chen Z, Chetty IJ, et al. The American Society for Radiation Oncology's 2015 core physics curriculum for Radiation Oncology residents. *Int J Radiat Oncol Biol Phys.* 2016;95:1298-1303.

Discussion

This update to the core curriculum addresses several issues. First, it provides an update to the curriculum after 8 years. This is a substantial span of time, especially in a field such as radiation oncology, which has rapid adoption of major technical innovations and treatment techniques. This update allocates time to recent developments such as adaptive radiation therapy, artificial intelligence and automation, contemporary radiopharmaceutical physics and dosimetry, brachytherapy isotopes, and an extended discussion on motion management. Second, the new charge of ROMPES filled the gap created after ASTRO sunset the PCCSC. Third, the realignment of the core curriculum facilitates resident learning by providing concordance between the guides for radiation oncology resident education and examination preparation.

The final issue is the COVID-19 pandemic and reshaping of the way we teach and learn as a society.[7] The 2015 curriculum does not provide guidance for instructors on how to teach, but rather what to teach. Given the challenges in teaching that we face today, several points warrant discussion. With the pandemic forcing new social distancing rules, traditional face-to-face learning was put on hold with the transition to virtual learning. It is uncertain if social distancing will continue to affect daily life, but we should consider virtual learning and how it can be effectively incorporated into residency education. A benefit of virtual learning is the ease of accessing the lecture. With the internet at our fingertips, a lecture can be delivered and viewed from almost anywhere. One of the major downsides to virtual learning is the ability to ensure that students are actively engaged in the lecture. One solution is a flipped classroom approach where the lectures are provided to the students beforehand and instructional time can be used for active learning strategies such as discussion sessions, question and answer sessions, or interactive case examples of topics rather than a traditional lecture format. This method can be difficult to implement initially but has been shown to be effective at multiple educational levels.[9] Although it can seem like a daunting task to implement a new style of teaching, there are examples of success in medical physics.[10] AAPM also provides some excellent resources to guide physicists as educators (https://www.aapm.org/education/ERG/TEACHPRES/MPESC.asp).

It is important to remember that each clinic is unique with a number of key variables factoring into the education offered: number of residents, number of physics faculty, resources, technology, etc. As a result, there might not be one consensus teaching method that works for your entire clinic, but as educators, it is imperative to communicate with your students. Critically examine what is working for student learning and eliminate what is impeding learning. Students should be encouraged to speak with program directors about how to improve teaching strategies. Open communication can help improve the culture of learning within the department. As educators and clinicians ourselves, we realize the formidable task of incorporating education into an already busy clinic schedule. We hope that if nothing else, this revision to the core curriculum motivates educators to reassess their current lecture process and the topics covered.

Ultimately, the 2 primary goals of this revision were to include new technology and promote concordance with resident education and examination preparation. With this in mind, ROMPES followed the title formats and content structures of the ASTRO 2004, 2010, and 2015 core physics curricula. Ideally, a full curriculum would include defined educational strategies, learning objectives, and assessment metrics, but inclusion of these new strategies was beyond the scope of this current revision. Future updates of the physics core curriculum will move toward a competency-based training assessment model to align with current educational trends in graduate medical education and radiation oncology.[11-13]

ROMPES is poised to fulfill the charges set by the AAPM. The inclusion of ROMPES members on the ABR Physics Study Guide Working Group will ensure that there is consistency between the curriculum and the ABR study guide. As new technology and treatment techniques emerge, ROMPES will be able to periodically update the curriculum. Future revisions of the curriculum will incorporate competency-based learning to follow the trends in graduate medical education. Finally, ROMPES plans to reach out to the radiation oncology community by surveying residency program directors and residents to ensure that the curriculum is relevant and helpful.

Conclusion

ROMPES has updated the core physics curriculum for radiation oncology residents. In addition to providing a comprehensive curriculum to promote best practice for radiation oncology practitioners, the updated curriculum aligns with recommendations from the ABR Physics Study Guide Working Group. New technology has been integrated into the curriculum. The updated curriculum provides a framework to appropriately cover the educational topics for radiation oncology residents in preparation for their subsequent career development.

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