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Editorial

Artificial Intelligence–Empowered Radiation Oncology Residency Education

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Introduction

Artificial intelligence (AI) employs computer algorithms sometimes trained on large, comprehensive data sets to simulate human intelligence to complete tasks, potentially improving efficiency and performance. This has led to significant advancements in many fields and is now permeating into academic radiation oncology (RO). As advances continue, we anticipate AI becoming more prominent in routine clinical practice and clinical education. Therefore, it will benefit RO trainees to understand the fundamentals of AI, including its application and limitations. Incorporating AI literacy into residency curriculum is being actively addressed in multiple single institutional and pan-institutional efforts; however, the utilization of AI to enhance residency education by supplementing traditional curriculum has not been extensively explored, especially by the RO community. This editorial will discuss how AI could bolster RO didactics, clinical encounters, contouring, and special procedures.

AI-Empowered Learning Tools

Didactics

Traditionally, RO didactics tend to be passive, with residents listening to lectures presented by attending or fellow residents. Contrastingly, flipped learning, shown to increase retention and peer engagement, is a style of learning where residents review the material prior, allowing time for in-depth discussion with the respective expert.[1] However, independently reviewing lecture material can be daunting, especially for junior residents, and initial guidance would be beneficial. In this context, AI could facilitate this process.

In AI-assisted flipped learning, AI could improve the searchability of current RO databases or possibly serve as virtual assistants. AI-driven search engine features, such as query completion and related topic identification used in Google searches and Dimensions AI,[2] could help RO residents quickly navigate relevant peer-reviewed material on PubMed, review contour guidelines on eContour, and practice review materials. Similar to Amazon chatbots used for customer service, AI virtual teaching assistants developed through natural language processing could answer common questions and save residents the frustration of navigating the deluge of various retrospective and prospective data that guide clinical decision making. Facilitating focused, unrestricted access to key learning material at home while allowing effective participation in group discussions can promote customized, in-depth learning with a focus on synthesizing new information and understanding clinical nuances later.

Given the tremendous computing powers of AI, we perceive the adoption of malleable models where visual learners can navigate a topic in virtual reality and auditory learners can experience a customized podcast. Toward the end of the immersive experience, trainees could consolidate their new expertise with links to broader resources, such as guidelines, consensus statements, and repositories of ongoing research.

Clinical encounters

The role of traditional RO didactics in preparing residents for new patient consultations is limited. Case-based learning (CBL) is an interactive learning modality using

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clinical vignettes to integrate theoretical medical knowledge into clinical applications, demonstrating effectiveness in educating health care professionals.[3] Specifically, CBL is particularly effective for simulating rare disease entities and possibly reducing inter-resident variability regarding exposure to uncommon cases. AI may advance CBL by extracting data from electronic medical records to generate a list of similar cases by disease site, anatomic complexity, and treatment modality. Thoroughly curated, de-identified clinical vignettes with comprehensive clinical data may serve as valuable educational resources for residents, supplementing their educational deficiencies in particular disease sites and preparing them for new patient encounters. When adding new clinical cases, AI algorithms immediately perform automated clinical data validation by conducting data quality control to ensure integrity.[4] Virti health care has already attempted to exploit AI to drive learning and development education content where physicians can practice their interpersonal skills and build empathy using AI-powered simulated patients.[5] Furthermore, there are examples of AI-guided teaching improving ophthalmology and surgical clerkship-based studying.[6,7]

During on-treatment and follow-up visits, the current approach manages adverse reactions for patients receiving radiation therapy in a reactive manner. Therefore, residents must learn to stratify patients based on risk categories. For example, AI algorithms can assist in predicting acute radiation toxicities by incorporating clinical and treatment variables. In addition, AI-generated compilations of relevant scientific articles on adverse reactions and complications from radiation therapy by disease sites and baseline risk factors could enhance residents' preparedness and response when dealing with high-risk patients.

Contouring

When residents learn to contour, their cases represent the patients seen in the clinic, which may not be well organized for gradual, systematic learning. Furthermore, significant contouring variations exist between providers, and even among clinical trial protocols, for similar disease sites. Therefore, we envision AI assisting with the next generation of interactive contouring resources by providing several examples of auto-contoured targets based on various physician styles which all meet the specified guideline/trial criteria.[8] Additionally, with further advancements in semantic segmentation, AI can act as a virtual mentor to provide real-time or postplan completion feedback on these indexed cases.

We picture residents using a step-by-step contouring guide to contour cases and receive real-time feedback from an online AI virtual mentor. Following an AI-organized contouring atlas stratified by disease site, difficulty, and treatment paradigm, novice residents can build confidence gradually by starting from simple cases and later being guided toward cases highlighting deficits in treatment-associated decisions. Thus, it is anticipated that adopting these resources will provide a framework for increased efficiency and interest in contouring.

Plan evaluation

Resident education in treatment planning varies widely based on the level of involvement with plan generation and review. Because an intuitive sense of what constitutes a "good" plan only comes with experience, residents would benefit from having more interactive and structured cases to review. We envision AI simulating the plan review process by initially acting as a virtual dosimetrist, intentionally generating a poor plan and subsequently revising the plan based on resident feedback. After the resident is content with the plan generated, AI would act as a virtual attending by providing feedback on what the optimal plan could have been with various modalities. The resident would gain an intuitive sense of when to accept and reject plans with requested revisions, and this would ideally result in more meaningful communication with treatment-planning staff. Residents would also understand when to use more sophisticated techniques to improve dosimetry around sensitive organs at risk.

Special procedures

One potential application for AI in RO would be to enhance procedural learning when it comes to procedures like brachytherapy, which may be especially important as its usage has declined over the past decade. Repeating exposure helps trainees recognize anatomic landmarks in different planes, differentiate normal from abnormal findings on imaging, and use brachytherapy at different anatomic sites. In surgical education literature, an AI application was used to automate technical skills assessment in robotic surgery. In this surgical innovation, the authors compiled surgical footage performed by expert surgeons to train a deep-learning neural network to gauge how closely novice trainees emulate the appropriate techniques.[9] A similar approach could guide RO residents when learning, for example, image-guided interstitial needle placement for prostate cancer.

Challenges and future directions

Implementing a new curriculum is a logistical challenge, especially with the disparities in available resources among institutions. Additionally, establishing a high-quality multi-institutional educational database may be arduous for all stakeholders. Acknowledging the limitations of these new technologies and understanding the benefits of AI-augmented learning is still paramount in improving RO residents' overall education experience. While most AI-based learning tools for RO residents have yet to be developed, a consensus on the importance of this mission and the necessity of investing in resources is crucial for the RO community. We believe this AI-empowered educational initiative is a contemporary approach to supplementing the traditional educational curriculum.

Conclusion

Incorporating AI-augmented learning tools in the traditional education curriculum for RO residents can facilitate expedited information acquisition, foster critical insights, and potentially compensate for educational gaps.

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