The Ever-Changing Role of Medical Physicists in the Era of Personalized Medicine

Current trends in oncology are undoubtedly oriented toward a patient-tailored, personalized approach. In this context, the role of medical physicists is more dynamic than ever. Those days when the responsibilities of the clinical physicists were limited to dosimetry, quality assurance, treatment planning, and radiation protection are long gone.[1]

With the growing complexity of the curriculum for medical physics trainees, topics from a great deal of adjacent subjects have been introduced and a significant number of physicists have broadened their interest in related fields. Radiobiology, risk assessment and analysis, data science, and medical statistics are only a few examples in this respect.

Furthermore, modern treatment techniques such as image-guided radiotherapy have led to a more pronounced interconnectivity between medical physics fields such as imaging and therapy, thus increasing the interest and knowledge of radiotherapy physicists in imaging and *vice versa*. Moreover, because treatment adaptation through biological optimization of treatment planning requires the consideration of radiobiological parameters, the role played by functional imaging in target redefinition resulted in increased attention from the physics community. The intertwined grounds of molecular imaging and treatment planning headed toward a multidimensional radiotherapy, which entails a more complex, patient-tailored approach.[2] Functional image analysis allows the implementation of biological parameters into radiobiological models that can assist treatment adaptation to the individual needs.

Radiobiological computational modeling has been greatly embraced by the medical physics community as it can serve several purposes: from basic tumor growth simulation and response to therapy,[3] to multiscale modeling of biological processes in tumors,[4,5] treatment planning evaluation,[6] and protocol optimization in radiotherapy.[7] Cellular automation as well as multiscale models have been developed and used for their flexibility that allows incorporation of diverse spatial growth features and parameters and also of agent-based treatment simulations guided by pre-established rules. By using tumor kinetics data, these models are able to predict tumor growth patterns and behavior, thus facilitating the evaluation of tumor response during treatment. *In silico* models in biological and medical research are remarkable tools in evaluating various scenarios which would otherwise be too demanding to study via *in vivo* research and even so in clinical trials. For instance, models are often used to simulate the existing trials in order to compare their outcome to the clinical reality. If the computed results fall within a small error margin to the clinical outcome, the model is deemed valid, and the software can be employed to simulate virtual clinical scenarios in order to obtain theoretical results. These results can be of great value for decision makers to channel oncology research and funding toward the most likely successful clinical trial.

For decades, the main focus of the medical physicist involved in radiotherapy was the treatment of primary tumors. Lately, to tackle one of the greatest burdens on today's oncology – the management of systemic disease, physicists became more involved in targeted therapies and in the development of new agents toward personalized treatment.[8] Targeted radionuclide therapy and radio immunotherapy are a few interdisciplinary subjects that have seen great developments over the past couple of decades, highlighting the impact of the physicists' involvement in the treatment of disseminated disease.

As the medical physicist is a player in a multidisciplinary team, his/her responsibility becomes more visible on a greater scale, through the involvement of our profession from bench to bedside implementation of new treatment approaches. The role of medical physicists in clinical trials includes all aspects from basic physics tasks to more complex assignments that involve image acquisition, segmentation and image registration, patient and target positioning (reproducibility, quality assurance), and treatment planning and delivery (accuracy of dose calculations and delivery, meeting planning goals, and end-to-end testing).[9] Furthermore, medical physicists are planned to be in the near future directly involved in patient care by explaining treatment planning and delivery aspects and answer the patients' technical questions.[10] Clearly, the duties of medical physicists are becoming more complex not only via new scientific/technical skills but also through new clinical roles.

But, perhaps, one of the most topical areas among medical physicists and, nevertheless, a greatly debated one is the applications of artificial intelligence (AI) in diagnostic imaging. In this respect, an emerging field in medical imaging that uses advanced machine learning (often referred to as generic AI) is radiomics. Radiomics refers to an algorithm-based extraction and quantification of image characteristics which lead to pattern identifications that are not visible to the naked eye. As demonstrated by a large number of studies, radiomics shows great potential in tumor phenotype classification, prognosis, prediction of treatment response and outcome, as well as personalized therapy. Of course, radiomics is not without its weak spots and comes with technological limitations that are yet to be addressed by the research community. Some of the challenges that are being worked on are concerning image reconstruction parameters, segmentation thresholds, reproducibility of radiomic features, and issues arising from intratumoral heterogeneity, all these tasks requiring better harmonization and standardization of image acquisition and feature computation.[11] And here begin other new challenges for the medical physicist…

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