Course Report

Advanced Physics for Brachytherapy

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Course directors:

- Dimos Baltas, physicist, University of Freiburg, Freiburg, Germany
- Panagiotis Papagiannis, physicist, National and Kapodistrian University of Athens, Athens, Greece

My name is Vasiliki Peppa. I am a postdoctoral researcher in the field of brachytherapy at the medical physics laboratory of the medical school at the National and Kapodistrian University of Athens, and I work as a medical physicist in the external radiotherapy department of the General Hospital of Athens ("Alexandra").

I was encouraged by Professor Panagiotis Papagiannis to participate in the advanced physics for brachytherapy course for two reasons: it was an opportunity for me to enhance my knowledge of recent advances in brachytherapy and the practices that are currently applied worldwide, and to look carefully at how research results are disseminated and translated into everyday brachytherapy clinical routines in order to narrow the gap between the discovery of new findings and their introduction to practice.

I gained in-depth knowledge of the role, advantages and limitations of the 3D imaging modalities that are currently used in modern brachytherapy techniques, the dosimetric uncertainties associated with the contouring, source path, image fusion, tissue segmentation assignment, composition and reconstruction of the seeds, needles, applicators and shields, and how these uncertainties could be addressed in real clinical scenarios to improve accuracy through the adoption of augmented commissioning and quality assurance procedures. The hands-on practice in the use of different imaging modalities for treatment planning covered a variety of clinical cases, which helped me not only to become familiar with the reconstruction process, but also to identify the uncertainties at each stage of reconstruction.

It was enlightening for me to review the limitations of TG-43-based dosimetry, quantify these limitations relative to reference Monte Carlo dose distributions for specific treatment sites, and assess their clinical significance. It was beneficial to have an in-depth understanding of the mathematics and physics of the algorithms that are involved in brachytherapy treatment planning systems that employ model-based dose calculation algorithms so that I could understand the dose discrepancies that were observed with respect to reference Monte Carlo dose distributions in real clinical scenarios as well as in test procedures. There was extensive discussion of experimental dosimetry in brachytherapy with regard to the characteristics and selection criteria of the utilised dosimeters and the stringent requirements that arose from the inherent dosimetry challenges in brachytherapy. This topic was directly linked to the challenging one of treatment delivery verification in brachytherapy. It became clear during this course that, although image guidance has become state-of-the-art at most brachytherapy treatment sites, the verification of treatment delivery in terms of commercially available systems that fit well into the clinical workflow has not been effectively developed yet. However, the analysis that was conducted on *in-vivo* dosimetry as well as on source tracking gave me food for thought regarding where we might be heading in the near future towards improving guidance, automation, verification and plan adaptation in brachytherapy.

The course exceeded my expectations! Information, communication, education, and expertise coalesced during this course. The scientific programme was very interesting, as it provided an overview of the current state of brachytherapy, from the scientific background to the most sophisticated clinical applications. A wide variety of theoretical and practical topics were addressed. These were relevant to treatment planning, image guidance, dose-calculation algorithms, experimental dosimetry, and quality assurance. The variety fulfilled the requirements of the multidisciplinary audience that participated in the course. The faculty demonstrated deep knowledge of the subject in every aspect and presented high-quality lectures. The organisation overall was professional and the sessions, which were structured for discussion, enabled an extensive, interactive exchange of ideas between the participants and the faculty.

My main takeaways from the course pertain to an understanding that brachytherapy is subject to several uncertainties that are associated with imaging, treatment planning, dose calculation, heterogeneity effects and anatomical changes. These must be detected and quantified in everyday clinical routines to improve treatment outcomes. In recent years, there have been major advances in the ways in which brachytherapy treatments are planned and delivered. These improvements include the incorporation of 3D imaging modalities for pre-planning, implantation and treatment verification, significant advances in treatment applicator design, adoption of model-based dose-calculation algorithms in the planning systems, and the availability of inverse planning and optimisation techniques, which enable the implementation of adaptive treatment planning and delivery routinely in the clinic. However, new brachytherapy treatments should be introduced cautiously into clinical practice, after the completion of robust clinical trials and with systematic error reporting. Further research must be conducted on the development of sophisticated quality assurance procedures that are appropriate for each stage of modern brachytherapy treatments.

From a researcher's point of view, this course helped me to understand that research projects in the challenging field of brachytherapy should be designed after the researcher has considered how the findings could be applied in clinical settings. I became strongly aware that the efficacy of practices in brachytherapy treatments must be demonstrated through prior research; that knowledge should be transferred out of research papers into the real world so that it is accessible to practitioners and patients. I carried back to the lab and my clinical routine a belief that the development and publication of practical recommendations, and the training and education of professionals about the processes and findings of research at each stage of brachytherapy, were the steps that would prove the most valuable for the dissemination of best practice in the clinical workflow.

I would definitely recommend this course to any professional who worked in the field of brachytherapy, since it provides a background to facilitate researchers' orientation towards practical problems and for practitioners to identify sources of uncertainties so that they can adopt appropriate solutions in their everyday clinical routines.

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