Editors Picks

Systematic Review of Intensity-Modulated Brachytherapy (IMBT): Static and Dynamic Techniques

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What was your motivation for initiating this study?

Our research team at the University of Iowa with Dr Flynn, Dr Wu and myself started to investigate the use of rotating-shield brachytherapy (RSBT) with inverse-optimisation of its shield sequence in 2010, due mainly to two challenges: first, the opportunity for physicians to train on interstitial brachytherapy cases was highly limited; and second, we found that laterally extended high-risk clinical tumour volumes (CTVs) that were clearly visualised on T2-weighted, 3 Tesla MR images, could not be properly covered to the desired dose using a Fletcher-style tandem and ovoids (T&O) applicator. The percentage of North American graduates of radiation oncology residencies who gain the skill sets of interstitial brachytherapy for gynaecological applications has decreased over the last few years. The idea of RSBT that Dr Flynn originated has grown and several research projects have been funded by the National Institutes of Health (NIH) (R01: principal investigator (PI), Dr Wu, and small business technology transfer research (STTR) phase 1: PI, Dr Flynn). The work has led to the publication of 13 papers and three patents. Meanwhile, other research groups have become interested in intensity-modulated brachytherapy (IMBT) approaches with dynamic or static shields. The common factor in all IMBT approaches is that they enable physicians to use their implant skill set of T&O and tandem-and-ring (T&R), while increasing conformality of coverage specific to each patient's tumour shape.

The approach of using static shields in brachytherapy has a long history. The prototypes of different IMBT applicators have recently been reported as built, most major brachytherapy treatment planning systems can be used to perform heterogeneous dose calculations, and an innovative partially shielded seed array (CivaSheet) is now commercially available. We thought there were enough published peer-reviewed articles on static and dynamic IMBT approaches for us to conduct a thorough review and report their promise and limitations systematically.

What were the main challenges during the work?

There were two major challenges to reviewing all IMBT approaches fairly and comprehensively. First, there were many innovative IMBT approaches that we decided not to report on in our paper, since they were reported in conference abstracts. One of our inclusion criteria was that reports needed to be peer-reviewed publications. This criterion existed out of practicality; there were so many published abstracts with limited information on the implementation that we were unable to extract the information we needed from such sources. Second, it was a challenge to classify each IMBT approach while respecting the author-defined terminology such as RSBT, dynamic modulated or direction-modulated brachytherapy (both abbreviated to DMBT) for high-dose-rate brachytherapy techniques, or CivaSheet or partially shielded seeds for low-dose-rate brachytherapy techniques. We had to classify those using a new classification rule: static versus dynamic IMBT and shielded source versus shielded applicator.

What is the most important finding of your study?

The most important information provided by this study is a comprehensive overview of the current status of developments in IMBT approaches, including their applicator and/or source designs, new high-dose-rate brachytherapy sources ideal for IMBT, innovative optimisation and dose-calculation algorithm to find optimal plans efficiently in a given IMBT hardware design, and their clinical validations mainly through dosimetric studies with minimal clinical trials.

What are the implications of this research?

The IMBT approaches still present challenges for clinical testing in terms of increased planning, optimisation, and delivery times, as well as a lack of fully developed prototype applicators and sources for most IMBT approaches. As a result, there is a dearth of adequate quality assurance (QA) and clinical validation of these techniques in the current literature. It is not clear whether IMBT approaches will replace the current clinical practice of using hybrid intracavitary plus interstitial applicators for gynaecological cancer or interstitial high-dose-rate brachytherapy for prostate cancer. However, the current IMBT literature presents a promising future for the brachytherapy field given the potential improvements in organ-at-risk sparing and tumour coverage, as well as the potential to decrease the complexity and invasiveness of implantation.

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