Editorial

Imaging for radiation treatment planning and monitoring in prostate Cancer: Precision, personalization, individualization of therapy

Radiation therapy plays an important role in the treatment of primary prostate cancer [1]. The significant advantages of radiation therapy in comparison to radical prostatectomy (also an important treatment option for this tumor entity), are the non-invasive character of the treatment and the relatively good results concerning preservation of urinary and sexual function. However, although the curative chance is high and the rate of side effects low, there are patients presenting either local recurrence after the treatment, or side effects, or both. The higher the irradiation dose the higher the tumor control, but also the higher the risk of side effects [2,3].

Visualization of gross-tumor volume in prostate, made possible by the recent developments of magnetic resonance imaging (MRI) and positron emission tomography (PET) techniques, gives rise to new strategies in the management of the primary prostate cancer through irradiation: hypofractionated radiotherapy, stereotactic radiation therapy/radiosurgery, focal external beam radiation therapy or brachytherapy and proton therapy [4].

This virtual special issue of *Physics and Imaging in Radiation Oncology* presents some of the new modalities for the visualization of prostate cancer *in vivo* using MRI and PET, and shows how these investigations improve target volume delineation for radiation treatment planning as well as treatment guidance and how they support a better evaluation or prediction of treatment results.

The issue addresses the anatomical imaging of the prostate, as visualized on MRI as compared to computed tomography (CT) and investigates its implications for target coverage and dose to organs at risk [5,6]. This issue also presents, on the other side, functional imaging techniques to localize and characterize prostate cancer. New PET tracers for this purpose are reviewed by Zamboglou et al. [7] and a study by Tulipan et al. [8] aims to identify if dynamic PET techniques reveal similar perfusion characteristics as dynamic contrast-enhanced MRI. Olsen et al. [9] provide a tutorial overview of the most common as well as a few upcoming functional MR imaging techniques that may serve as a tool towards individualized radiotherapy. The characteristics of the prostate cancer as revealed on MRI, may also have potential as biomarkers for outcome of the treatment. Two studies investigate radiomics feature analysis of MRI, both anatomical (Fernandes et al.) [10] and diffusion-weighted MRI (Lee et al.) [11] for this purpose.

These studies are all in line with the future goals of radiation oncology to visualizing (through highly sophisticated imaging methods) both the morphology and the biological characteristics of tumor and organs of risk [12]. Understanding these characteristics will enable a differentiated dose delivery and fractionation, forming this way the basis for a **personalized treatment** in radiation oncology. Algorithms computing and mapping the likelihood of tumor presence, tumor-control probability (TCP), and normal-tissue-complication probability (NTCP), will also feed on these tumor/normal tissue characteristics and improve this way the treatment outcome. Finally, the delivery of such personalized treatments with sophisticated dose distributions, requires a **high precision** in treatment delivery. Pedersen et al. [13] applied dose response models for both tumor control and normal tissue complications to explore the benefit of proton therapy (PT) combined with focal tumor boosting, also when accounting for inter-fractional motion. Two studies in this issue address the potential improvement of treatment plans [14] and the clinical experience [15] with MRI-guided radiotherapy to realize this level of treatment **individualization.**

Three concepts define the modern medicine: **precision, personalization and individualization**. A deep understanding and an appropriate utilization of imaging in radiation oncology will help to achieve these goals. Prostate cancer presented in this issue is a model – lessons learned here could be extrapolated to other tumor entities.

Declaration of Competing Interest

The authors declare no conflicts of interest.

References

[1] Mottet N, Bellmunt J, Bolla M, Briers E, Cumberbatch MG, De Santis M, et al. Guidelines on prostate cancer. Part 1: screening, diagnosis and local treatment with curative intent. Eur Urol 2017;71:618–29.

[2] Kishan AU, Cook RR, Ciezki JP, Ross AE, Pomerantz MM, Nguyen PI, et al. Radical prostatectomy, external beam radiotherapy, or external beam radiotherapy with brachytherapy boost and disease progression and mortality in patients with gleason score 9–10 prostate cancer. JAMA 2018;319:896–905.

[3] Viani GA, Stefano EJ, Afonso SL. Higher-than-conventional radiation doses in localized prostate cancer treatment: a meta-analysis of randomized, controlled trials. Int J Radiat Oncol Biol Phys 2009;74:1405–18.

[4] Baumann G, Haider M, Van der Heide UA, Menard C. Boosting imaging defined dominant prostatic tumors: a systematic review. Radiother Oncol 2013;107:274–81.

[5] Gunnlaugsson A, Persson E, Gustafsson C, Kjellén E, Ambolt P, Engelholm S, et al. Target definition in radiotherapy of prostate cancer using magnetic resonance imaging only workflow. Phys Imaging Radiat Oncol 2019;9:89–91.

[6] Ruiz B, Feng Y. Clinical and radiobiological evaluation of a method for planning target volume generation dependent on organ-at-risk exclusions in magnetic resonance imaging-based prostate radiotherapy. Phys Imaging Radiat Oncol 2018;8:51–6.

[7] Zamboglou C, Eiber M, Fassbender TR, Eder M, Kirste S, Bock M, et al. Multimodal imaging for radiation therapy planning in patients with primary prostate cancer. Phys Imaging Radiat Oncol 2018;8:8–16.

[8] Tulipan AJ, Vlatkovic L, Malinen E, Brennhovd B, Hole KH, Lie AK, et al. Comparison of time curves from dynamic 18F-fluciclovine positron emission tomography and dynamic contrast-enhanced magnetic resonance imaging for primary prostate carcinomas. Phys Imaging Radiat Oncol 2018;7:51–7.

[9] Olsson LE, Johansson M, Zackrisson B, Blomqvist LK. Basic concepts and applications of functional magnetic resonance imaging for radiotherapy of prostate cancer. Phys Imaging Radiat Oncol 2019;9:50–7.

[10] Dinis Fernandes C, Dinh CV, Walraven I, Heijmink SW, Smolic M, van Griethuysen JJM. Biochemical recurrence prediction after radiotherapy for prostate cancer with T2w magnetic resonance imaging radiomic features. Phys Imaging Radiat Oncol 2018;7:9–15.

[11] Lee SL, Lee J, Craig T, Berlin A, Chung P, Menard C, et al. Changes in apparent diffusion coefficient radiomics features during dosepainted radiotherapy and high dose rate brachytherapy for prostate cancer. Phys Imaging Radiat Oncol 2019;9:1–6.

[12] Zamboglou C, Carles M, Fechter T, Kiefer S, Reichel K, Fassbender TF, et al. Radiomic features from PSMA PET for non-invasive intraprostatic tumor discrimination and characterization in patients with intermediate- and high-risk prostate cancer – a comparison study with histology reference. Theranostics 2019;9:2595–605.

[13] Pedersen J, Casares-Magaz O, Petersen JBB, Rørvik J, Bentzen L, Andersen AG, et al. A biological modelling based comparison of radiotherapy plan robustness using photons vs protons for focal prostate boosting. Phys Imaging Radiat Oncol 2018;6:101–5.

[14] Christiansen RL, Hansen CR, Dahlrot RH, Bertelsen AS, Hansen O, Brink C, et al. A biological modelling based comparison of radiotherapy plan robustness using photons vs protons for focal prostate boosting. Phys Imaging Radiat Oncol 2018;6:101–5.

[15] Teta SU, Bruynzeel AME, Lagerwaard FJ, Slotman BJ, Bohoudi O, Palacios MA. Clinical implementation of magnetic resonance imaging guided adaptive radiotherapy for localized prostate cancer. Phys Imaging Radiat Oncol 2019;9:69–76.

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