The effect of contouring variation on biochemical recurrence following prostate radiotherapy

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Phiro poster award

What was your motivation for initiating this study?

The assumption that we need perfect contours is always in our minds, but there is no solid evidence that helps us to determine the impact of any unavoidable imperfections in the contours on treatment outcome. Our main objective was to try to shed light on these aspects.

What is the most important finding of your study?

The most important contribution of our study is the proposal of a methodology that enables us to start to study the effect of contour variation, which is unavoidable, in large patient cohorts. The study was centred on prostate-cancer patients and we found regions where contour variation was correlated with biochemical recurrence. Once we confirm these findings, we can identify regions on which we can focus our efforts to reduce contour variation.

What are the implications of this research?

If we can confirm the findings and therefore identify regions on which we can focus our efforts to reduce contour variations, we hope to influence future contouring guidelines to enable treatments to have greater accuracy and therefore bring better outcomes for patients.

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Predictors of incontinence two years after post-prostatectomy radiotherapy: evidence of dose & fractionation effects

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Physics poster award

What was your motivation for initiating this study?

Urinary incontinence is a side effect of prostate-cancer radiotherapy that is actually very common despite the use of modern techniques, and it is highly detrimental to patients' quality of life. Indeed, the reported incidence of severe, late incontinence ranges between 1% and 5% in radical radiotherapy, but increases up to more than 20% in the post-prostatectomy setting. To date, the role of dose and fractionation in increasing the risk of persistence or worsening of post-operative urinary incontinence is controversial and no robust data are available. Our high-quality data, which were collected within the registered multi-institutional cohort study that was entitled intestinal haematological urinary toxicity from whole-pelvis radiotherapy (IHU-WPRT TOX, clinicaltrials.gov identifier #NCT02803086), were suitable for the development of predictive models in this perspective too.

What is the most important finding of your study?

The most important result of the study is a two-variable model for the objective of patient-reported urinary incontinence symptoms (PRUI) in the first two years after post-prostatectomy radiotherapy. The analysis has clearly highlighted for the first time that there is an independent correlation between PRUI, which is predominantly influenced by the frequency of urine leakage, and equivalent total doses in 2Gy fractions (EQD2), where the best fit was achieved using an alpha-beta ratio equal to 0.8 Gy. Interestingly, the most predictive factor of two-year incidence risk was found to be the baseline level of urinary incontinence at the start of radiotherapy for all the clinically significant endpoints.

What are the implications of this research?

The study outlined the marked impact of baseline symptoms, dose and fractionation on the risk of late, severe urinary incontinence after post-prostatectomy radiotherapy. In particular, the risk for patients who experienced mild symptoms at baseline was 20-30% higher than the risk for those who were "completely dry" at the start of radiotherapy. Surprisingly, the incontinence rate in the completely dry subset, which represented the optimal baseline recovery, was dramatically higher than the one that is reported in the literature for radical radiotherapy. This result suggests that the clinical scenario is largely influenced by the "memory" of surgical injury. More details are reported in Bresolin et al. (Front Oncol. 2020 Jul 23;10:1207. doi: 10.3389/fonc.2020.01207).

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Correction for ion recombination in a built-in monitor chamber at ultra-high dose rates

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Oral contribution

What was your motivation for initiating this study?

Currently, there is no standardised dosimetry protocol that is suitable for ultra-high dose rate electron beams. To ensure safety and dosimetric accuracy in the clinical translation of radiotherapy at ultra-high dose rates, novel solutions for online monitoring of the dose delivery are required. A cost-effective approach would be to use the linear accelerator's built-in transmission chamber, corrected for the severe ion recombination loss at ultra-high dose rates.

What is the most important finding of your study?

We were able to describe accurately the ion-collection efficiency in the chamber as a function of dose-per-pulse, through use of a logistic function. At the standard polarising voltage of -320V that is applied over the chamber, the ion-collection efficiency at ultra-high dose rates was too low to obtain accurate dose calculations. However, by tripling the polarising voltage, the ion-collection efficiency could be increased enough to calculate the absorbed dose accurately.

What are the implications of this research?

In this study we present a method to make the built-in transmission chamber useful for real-time dosimetry at ultra-high dose rates. We believe that, through the use of this approach, we will be able to bring clinical dosimetry at ultra-high dose rates up to the demanding standards of conventional radiotherapy.

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Prospective validation of a radiomics signature for chemoradiotherapy of lung cancer patients

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Oral contribution

What was your motivation for initiating this study?

Our motivation was to demonstrate prospective clinical evidence for a radiomics signature that predicted overall survival. Naturally, we built upon the original proof-of-concept (Signature-0) study (Aerts et al. Nature Communications, 2014;5:4006), which kick-started the whole field back in 2014, to achieve this goal.

What is the most important finding of your study?

Signature-0 is prospectively validated. Performance metrics for favourable vs. unfavourable outcomes in non-small-cell lung cancer (NSCLC) patients treated by chemoradiotherapy were consistent between model development, internal validation, external validation, and prospective validation across more than 1000 patients. Furthermore, Signature-0 can be used to stratify with high-accuracy patients who have very favourable vs. very unfavourable outcomes.

What are the implications of this research?

This has implications for the wider field as it demonstrates that other signatures could also be prospectively validated. This signature could be used as a clinical decision support tool to evaluate the likelihood of response of NSCLC patients who are treated by chemoradiotherapy. This could be used in practice in treatment planning to justify additional emphasis on the addition of chemotherapy and/or the optimisation of the dose to the gross tumour volume (GTV) in patients classified as non-responders. Conversely, this could be used in treatment planning to justify additional emphasis on the optimisation of reduced dose to the organs at risk (OAR) in patients who are classified as responders. Other potential applications of this signature include its use as a stratification tool in future trials or evaluation of elderly patients for whom we have no randomised trial outcome data.

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An anomaly detector system for parotid gland delineations

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Oral contribution

What was your motivation for initiating this study?

Delineation of organs at risk is a tedious process for the clinician. While helpful, the recent development of auto-contouring software still requires the clinician to check and verify the structure prior to treatment. This judgement, however, is non-trivial and can be time-consuming. An anomaly-detector system may be useful to assist in the identification of which contours require corrections and which do not.

What is the most important finding of your study?

The anomaly detector we developed achieved a high sensitivity rate, in a range of different anomalies that we tested, while at the same time the false negative alarm was kept very low. Several interesting anomalies appeared in clinical contours that revealed a potential lack of clinical consensus and raised important conversations among clinicians. An example of such a case was an over-contouring of the parotid lateral ducts, which appeared sporadically in the data.

What are the implications of this research?

Many of the things we check in radiation oncology are in essence 'anomaly detection', as we aim to catch potential harmful errors before the treatment begins. Especially in the era of automation and artificial intelligence, such systems will be extremely valuable to verify to clinicians that it is safe to proceed with the treatments as well as to standardise our clinical practice.

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Voxel-wise analysis of rectal toxicity associations using accumulated delivered dose

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Oral contribution

What was your motivation for initiating this study?

The study was part of the VoxTox research programme. This was an exciting study that used daily megavoltage-computed tomography (MVCT) and image-guided radiation therapy (IGRT) images to calculate and accumulate daily delivered doses. The hypothesis was that delivered dose was a better predictor of toxicity than planned dose. The motivation for this study was to analyse the delivered dose to the rectum in prostate radiotherapy through the use of novel tools such as finite element modelling and probabilistic subregion analysis to explore the link between voxel-level dose and toxicity.

What is the most important finding of your study?

The study showed that delivered dose could be a stronger predictor of rectal toxicity than planned dose, and that spatial dose patterns of the rectal wall could be more strongly linked with toxicity side effects than metrics that represented the full dose distribution (e.g. equivalent uniform dose). This indicates that intra-organ dose response is non-homogeneous and suggests that inclusion of spatial dose features may improve dose-toxicity prediction models.

What are the implications of this research?

This research presents the first analysis that links daily accumulated dose at the voxel level with rectal toxicity in prostate radiotherapy. It complements analysis that has been conducted using planned dose alone or estimates of delivered dose. We anticipate that the findings will be useful to streamline delivered dose relationships into an adaptive radiotherapy workflow, as well as in future investigations into ways to reduce toxicity incidence.

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Ultrasound-guided PBS proton-beam tracking in lung using a statistical motion model

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** shared the first authorship*

Oral Contribution

What was your motivation for initiating this study?

The treatment of moving targets is one of the major challenges in modern radiotherapy, particularly in pencil-beam scanning (PBS) proton therapy. On the other hand, PBS lends itself to tumour tracking, as the beam position can be adapted rapidly and continuously. However, protons are very sensitive to density changes along the beam path, so real-time knowledge of three-dimensional anatomy is required in order to track the tumour accurately in width and depth. Use of abdominal ultrasound (US) imaging, which provides internal, two-dimensional respiratory information, in combination with a respiratory motion model seemed a promising approach to reach this goal.

What is the most important finding of your study?

US imaging in combination with our motion modelling framework is a feasible approach for prediction of real-time, three-dimensional motion of the lung. Model-based results were found to be comparable with reference simulations. Interestingly, though, tumour tracking with or without adjustment of proton range was found to be similarly effective. However, tracking alone cannot guarantee clinically acceptable dose distributions, particularly in the case of major tumour deformations.

What are the implications of this research?

Our approach could be applied to any image-guided radiotherapy technique in cases in which knowledge of real-time, three-dimensional lung motion is required. The fact that non-range-adjusted tracking may be as effective as full 3D tracking could simplify the clinical application of proton tracking. However, for large motions and deformations, tracking alone is not precise enough to be used on its own, and will have to be used with additional motion mitigation strategies such as rescanning, gating or 4D optimisation.

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