plans before DLG adjustment all showed negative deviations of 3.12−3.8% (PTV mean/max).

Conclusions. A random sample of treatment plans were within 2.5% in absolute mean dose of the PTV between Mobius3D and the TPS. MLC parameter optimization plays an important role in establishing an acceptance criterion.

https://doi.org/10.1016/j.ejmp.2018.06.108

**[OA037] Advanced dose calculation algorithms in lung cancer radiotherapy: Implications when treating in deep inspiration breath hold**

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Purpose. Modern dose calculation algorithms model absence of lateral charged particle equilibrium to a limited extent. The resulting dose calculation uncertainties are most noticeable in strongly heterogeneous regions, like the thorax, and will increase in deep inspiration breath hold (DIBH) due to decreased lung tissue density.

Methods. For 17 stage I and 17 stage III lung cancer patients, a plan in free breathing (FB, based on midventilation) and in DIBH were generated with Anisotropic Analytical Algorithm (AAA). Stage I disease was treated with 3D-conformal stereotactic radiotherapy (SBRT), 45 Gy in 3 fractions, prescribed to 95% isodose covering 95% of PTV and aiming for 140% dose centrally in the tumour. Stage III disease was treated with volumetric modulated arc therapy (VMAT), 66 Gy in 33 fractions, prescribed to mean PTV dose. Calculation grid size was 1 mm for stage I and 2.5 mm for stage III. All plans were recalculated with AcurosXB with same MU as in AAA, for comparison on target coverage and dose to risk organs.

Results. Lung volume increase in DIBH resulted in 6% decreased lung density for stage I (from median –757 HU to –811 HU) and 12% for stage III (from median –723 HU to –822 HU). In stage I, AAA overestimated all PTV parameters (p-values <0.01) compared to AcurosXB, with largest impact in DIBH. Mean dose and D98% were underestimated by 2.0/2.3 Gy in FB and 3.1/4.0 Gy in DIBH. These clinically relevant differences may be a combination of small targets and large dose gradients in the SBRT treated volume. In stage III, AAA systematically overestimated the target coverage compared to AcurosXB. D98% was overestimated by median 1.1/1.2 Gy in CTV and 1.5/2.1 Gy in PTV, in FB and DIBH respectively (p < 0.01). Hot spots (estimated as D2%) did not differ between AAA and from AcurosXB, in both FB and DIBH. No significant difference was observed for lung and heart dose parameters between the algorithms, for both FB and DIBH, in the two patient cohorts.

Conclusions. Choice of calculation algorithm impacts the calculated dose distribution in the target. AAA overestimated target coverage compared to AcurosXB, especially in DIBH for stage I lung cancer treated stereotactically.

https://doi.org/10.1016/j.ejmp.2018.06.109

**[OA038] Does automation reduce the number of errors in quality control of treatment plans for external beam radiotherapy?**

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Purpose. Any single treatment plan error should be detected and corrected prior to treatment either during a check procedure or by built-in safety features of the treatment planning (TPS) or record and verify systems. However, as delivery techniques have become increasingly complex the number of possible errors in a plan has increased dramatically. It is therefore desirable to automate as many check procedures as possible to eliminate manual errors. In this work we investigate the effect on error rates of introducing automation in quality control of patient treatment plans.

Methods. Dose constraints, fractionation and best practice guidelines for all treatment schemes in our clinic taken from relevant guidelines (institutional, national, international or clinical trial) were collected in a database. A TPS script was written to generate a report comparing plan information with reference values from the database as pass/fail criteria. To determine if automation reduces the number of errors compared to manual quality control, 322 consecutive plans approved for treatment with manual quality control between September 1st and October 1st 2017 were retrospectively subjected to automated quality control with the script. All errors were recorded and severity was scored using the recommendations from the AAPM TG-100 report.

Results. 320 errors were detected in 10,243 individual checks (3.1%). Three errors were found to have had impact on target dose, ranging from 0.5% (severity 5) to 7% (severity 7), while another 18 could have caused either geographic or dosimetric impact (severity 5+). The remaining 299 errors were either purely clerical or could at worst cause minor inconvenience to staff, severity score 1–2.

Conclusions. Automation of treatment plan quality control reduces error rates and increases adherence to guidelines compared to a purely manual workflow.

https://doi.org/10.1016/j.ejmp.2018.06.110

**[OA039] Contouring and dose reporting for lower urinary tract sub-structures in cervix cancer**

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Purpose. Radiotherapy related bladder morbidity include various clinical endpoints (i.e. frequency, cystitis, incontinence, bleeding, fistula) that may be related to various anatomical sub-structures.
Evaluation and reporting of bladder dose is currently based on the total bladder volume with contouring of the outer wall. This study aims to investigate contouring and dose evaluation of several bladder sub-structures potentially responsible for urinary morbidity after radiochemotherapy and Image Guided Adaptive Brachytherapy (IGABT) in locally advanced cervical cancer (LACC).

Methods. The study hypothesis is that different bladder structures are related to different morbidity endpoints. Therefore, a methodology for contouring subvolumes (trigone, bladder neck, urethra) was established. Structures were contoured for all BT fraction extracting DVH parameters: outer bladder wall (D2 cm3, D0 cm3), ICRU Bladder point, trigone (D2 cm3, D1 cm3), bladder neck (D2 cm3), and urethra (volume, D0 cm3, D2 cm3). A total of 40 LACC [FIGO Stage: Ib(3), IIb(30), IIIa(1), IIib(1), IVb(5)] patients according to the EMBRACE protocol was selected.

Results. The reported values represent the cumulative EBRT+BT dose in EQD2. Median D2 cm3 Values were 71.7 [59.2–81.8] and 56.2 [47.8–69.3] Gy for bladder wall and trigone, respectively. Bladder wall dose was systematically higher, and hotspots often placed outside the trigone. Median ICRU point dose was 63.0 [49.8–80.5] Gy. Median D1 cm3 values for bladder wall, trigone, bladder neck and urethra were 85.6 [58.2–109.8], 70.9 [48.3–105.6], 61.7 [46.5–76.9], and 50.6 [45.6–64.7] Gy, respectively. Median urethra volume and D2 cm3 dose were 3.2 [1.4–6.5] cm3 and 47.9 [44.8–58.7] Gy, respectively.

Conclusion. The study showed that the parameters currently used for IGABT bladder dose reporting (D2 cm3, ICRU point) do not fully and accurately describe the dose distribution in the lower urinary tract sub-structures. D2 cm3 for the outer bladder wall is often higher than trigone dose and in many cases the ICRU bladder point is not a good indicator. It is interesting to note that urethra volume may be relevant for endpoints such as incontinence varied across patients. Further understanding of dose-effect relationships for the bladder may be gained by future systematic delineation of bladder sub-structures.

Reference

https://doi.org/10.1016/j.ejmp.2018.06.112

[OA040] Quantifying the effect of increased tissue definition on inter-observer contouring of organs at risk in lung cancer patients using motion-compensated imaging
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Purpose. The development of 4DCT imaging allows clinicians to account for movement of both the target tumour and organs at risk, although the choice of method of image reconstruction can impact how accurately observers can contour nearby organs. Motion-compensated (MC) image reconstruction is a technique that reduces blurring compared to standard averaged reconstruction. This study aims to quantify the presence of sharper boundaries by taking the value of the image gradient at contour lines, and link this increase in tissue definition to lower inter-observer variation.

Methods. Eight patients with early stage non-small lung cancer were imaged with 4DCT, and these scans were reconstructed using both motion-compensated and averaged techniques. These two sets of scans were then each delineated by five clinicians, who contoured nearby organs at risk. The mean distance between observers’ contours was calculated and compared to the image gradient value at each point on the delineation.

Results. Drawing on results by McWilliam et al. [1], the use of motion-compensated CT image reconstruction results in a reduction in inter-observer variation across all sites delineated. The use of MC increases definition of boundaries between organs, represented by an increase in the image gradient at the delineation boundary. This result was particularly pronounced around the trachea, where preliminary results show the use of motion-compensated reconstruction reduced delineation separation by 50%; across all patients, the heart saw very little improvement between imaging techniques.

Conclusions. The use of motion-compensated CT reconstruction produces images with more well-defined boundaries between tissue, and higher values of image gradient. When delineating organs at risk, the presence of large gradients is a statistically significant (p < 1E–4) predictor of inter-observer agreement. Regions where this effect was not seen—specifically the heart—is thought to be due to additional organ motion not accounted for when reconstructing the scan.

Reference

https://doi.org/10.1016/j.ejmp.2018.06.112

[1041] Spatial distortions in MRI
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Purpose. MR images inherently suffer from spatial distortions. Spatial distortions play an important role particularly in quantitative MRI, where MRI parameters are employed as quantitative biomarkers, and in MRI-based treatment planning for advanced radiotherapy applications, which require high spatial accuracy in target localization and definition.

Methods and results. Spatial distortions stem from sources which either relate (sequence dependent distortions) or do not relate (non-sequence dependent distortions) to the measurement conditions (field strength, pulse sequence, scanning parameters, etc). Non-sequence dependent distortions arise from gradient field non-linearity and, thus, are related to the MRI system. Although MRI scanners utilize post-imaging correction algorithms which reduce gradient field non-linearity distortions, residual distortions may still be considerable at areas distant from the isocenter. These can be estimated and corrected with the aid of specially designed phantoms. Sequence dependent distortions arise from static magnetic field inhomogeneity ($\Delta B_0$), magnetic susceptibility ($\Delta B_s$) and chemical shift ($\Delta B_c$) phenomena, collectively referred to as field inhomogeneities, which may be machine-related ($\Delta B_0$), or patient-induced ($\Delta B_s$ and $\Delta B_c$). Sequence dependent spatial distortions scale linearly with $B_0$ and can be partly controlled through the optimization of the scanning parameters and conditions that affect them. How-