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Salvage stereotactic external beam re-irradiation for prostate cancer local failure: finding safe dose constraints for principal organs at risk

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Purpose: The number of patients undergoing a retreatment for PCa recurrence is increasing. Salvage radiotherapy could be a valid non-invasive treatment option, but its use is limited because both of the lacks of data about toxicity and safe dose-volume limits. The purpose of the study is to analyse the dosimetric data of both treatments in order to find the dose-volume values to limit the OARs toxicity.
Materials and Method: The toxicity and dosimetric data of twenty-six patients, treated in our Institution with different techniques both for PCa and for intraprostatic relapse from 1998 to 2016, were analyzed. As the treatment protocols and the techniques changed consistently during the time, data were homogenized in terms of dose per fraction, i.e. each dose-volume curve was converted, according to the Linear-quadratic model, in normalized total dose equivalent to 2Gy (NTD2). The resulting dose volume histograms of the summed plans were evaluated. The side effects, namely chronic GI and GU toxicities, were related to OAR dose-volume histograms. A rough estimation of the constraints applied to the bladder and to the rectum for the whole treatment was done by converting the dose-volume limits into NTD2.
Results: About GI toxicities, due to the low number of analyzed patients and GI events, no statically significant correlations were found between dose-volume points and toxicities. In the GU toxicity case, more patients (10/26 pts) reported G≥2 chronic toxicities however, no statically significant correlations were found neither in this case. The mean DVH histograms of the bladder and the rectum were lower than the constraints applied for the two treatments.
Conclusions: Rectum: as the number of the detected adverse events is very low, our median DVH could be proposed as a reference to define the limits for this organ during the prostate re-irradiation.
Bladder: Due to the not negligible number of adverse events, it could be suggested to lower the doses to this organ below those represented in the median DVH.
Keywords: recurrent prostate cancer, salvage external beam radiotherapy, dosimetric constraints

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Deep learning method for tomotherapy delivery quality assurance: prediction of three-dimensional dose distribution and performance evaluation on phantom

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Purpose: High-tech radiotherapy capable to provide complex dose delivery modalities is one of the most important treatment modalities for cancer patients, making essential to evaluate with accuracy the clinical machine performances and the quality of the treatment plans [1–3]. The operation of Delivery Quality Assurance (DQA) is repetitive and involving both workforce and Linac bunker occupational time. To work around this problem, we developed new deep neural network models capable of predicting passing rates a priori for Helical Tomotherapy (HT) DQA in 3D voxel-by-voxel dose prediction. In this paper we evaluated net performances, focusing on learning quality in function of specific machine parameters.
Materials and Method: several deep neural network architectures (convolutional neural networks (CNN) and dynamic graph neural networks (DGCNN)) have been studied, able to extract and learn complex high-level features starting from raw HT information. We use planned sinograms and plan parameter information extracted from the machine database files to train the deep neural networks to predict 3D voxel-by-voxel delivered doses. For the training, HT data corresponding to 1009 patients were collected. All patients were previously planned and treated by TomoTherapy System (Hi-Art Model, ACCURAY, San Camillo-Forlanini, RM, ITA) between year 2013 and 2019. DQAs were retrospectively and randomly collected from hospital database.
Results: VGG, Xception, ResNet, and DGCNN have been optmized using cross-validation, data-augmentation, and model distillation techniques to limit effects from the finite size of the training sets. Performances have been evaluated by comparison with simulation, and with the planar doses measured in a phantom planar detector. In Figure 1 the MAE value as a function of the DQA delivery date, and

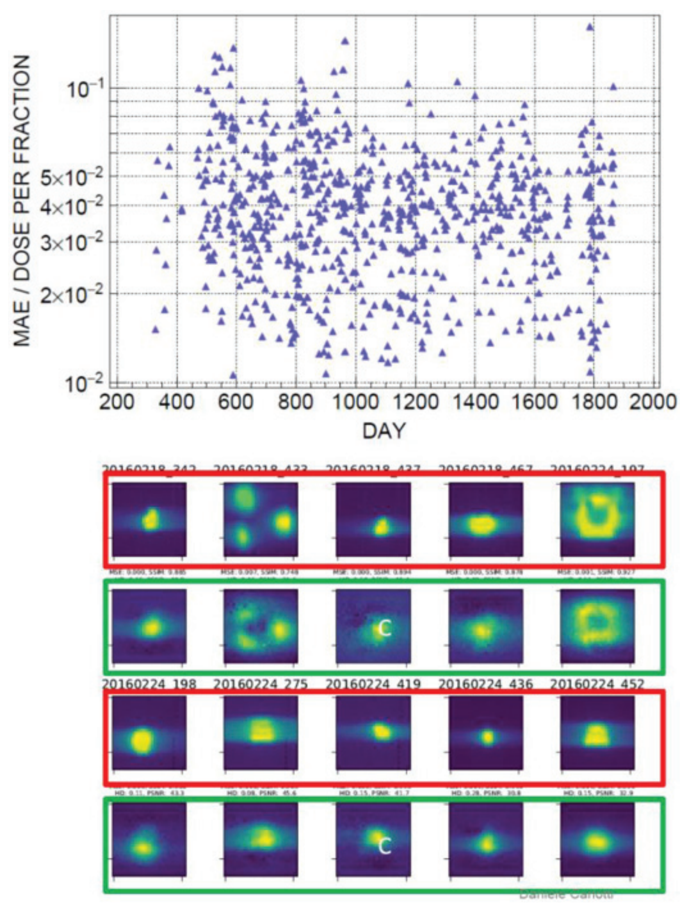

Fig. 1 (abstract P120). (a) MAE/Dose per Fraction. (b) Comparison of planar doses measured in the detector (red circled) and predicted by the VGG deep neural network model (green circled).

an example of comparison of planar doses measured in the detector and predicted by the VGG model, are shown.

Conclusions: In this study we present a novel Deep Learning methodology for 3D voxel-by-voxel dose prediction, able to reproduce results in HT. The method is promising and open the possibility for improving over current state-of-the-art DVH-based prediction and planning techniques.

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References:

[1] G. Valdes et al., Med Phys 2016;43(7).
[2] S Yartsev, T. Kron, J. Van Dyk, Biomed Imaging Interv J. 2007;3(1):
[3] M. J. Nyflot, P.s Thammasorn, W. Art Chaovalitwongse, Med. Phys. 2018;46(2).

Keywords: deep leaning, tomotherapy, dose prediction, quality assurance

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Automatic segmentation of prostate on TRUS images using convolutional neural networks

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Purpose: Prostate segmentation is an important part of brachytherapy treatment planning, in order to perform accurate needle placements. So far, segmentations are created manually and therefore it is a time-consuming, tedious and prone to inter-observer bias process. An automatic segmentation algorithm, will not only simplify the process, but also will standardize the output. Recently deep learning algorithms were presented to tackle this problem. However, these methods need a lot of training data and parameters to be optimized. In this work we present a deep learning based algorithm for segmentation of the prostatic gland on TRUS datasets which requires only a fraction of training data compared to existing methods with competing results.

Materials and Method: Our model is a modified version of the fully convolutional neural network for volumetric image analysis V-net by Lei et al, 2019. With only one final activation function instead of four. In a pre-processing step all images were normalized by z-score normalization to zero mean and standard deviation of one. Then an input ROI was automatically defined and resampled to a resolution of 128x128x128, using spline interpolation method. To compensate of the small dataset size and to avoid overfitting, augmentation methods such as random rotation in range of -20 to 20 degrees and 2D elastic deformation of each slide in transversal plane were used. The network was trained using batches of 100 images in 35 epochs, in approximately 9 minutes per epoch. We evaluated our algorithm on 22 patients from 2 different hospitals with 11-fold cross validation. Manual expert contours served as ground truth.

Results: With only half of the datasets compared to other studies done in last few years, we were able to achieve Dice score of 86.5, Hausdor distance of approximately 9mm and average surface distance of 1.7mm with no difference in performance between the patients from different hospitals. Computation time to generate the contour for one 3D TRUS volume is below 1 second.

Conclusions: In this work we were able to show that fully automatic segmentation of the prostatic gland for brachytherapy planning is possible with only a small amount of training data at an expert level quality. Clinical eligibility will be proven on a bigger validation cohort but the short computation time and the competitive results are encouraging.

Keywords: prostate, brachytherapy, segmentation, deep learning, TRUS

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Stereotactic radiosurgery for multiple brain metastases: dosimetric performance of two planning techniques and two setup approaches

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Purpose: To validate treatment planning system (TPS) calculated dose distributions of SRS-VMAT multiple brain metastases treatments, utilizing single- and two-isocenter techniques, using Gafchromic™ EBT3 films.

Materials and Method: A PMMA cylindrical phantom specially designed for dose verification, was selected to validate SRS-VMAT multiple brain metastases treatments, with the use of EBT3 films. Five targets positioned at distances up to 10cm to each other were contoured, simulating a multiple brain metastases case (approximately 1–2cm in diameter). Two SRS-VMAT plans were created in Monaco version 5.10, (ELEKTA, Crawley, UK) TPS, using a single and two isocenters and the X-Ray Voxel Monte Carlo (XVMC) dose calculation algorithm with a uniform dose calculation grid resolution of 1mm. The phantom was utilized to accurately reproduce every link of the treatment chain and irradiated for both treatment plans in an Axesse beam-modulator linear accelerator with Hexapod robotic treatment couch capable of applying corrections in all six degrees of freedom (i.e. both translational and rotational) with EBT3 film pieces, from a batch calibrated at a secondary standard laboratory, placed at the central coronal plane. Phantom was positioned at the treatment couch by performing Cone Beam Computed Tomography (CBCT) and applying the suggested a) only translational and b) both translational and rotational set-up corrections. Measured and TPS calculated dose distributions were spatially co-registered and compared in terms of 3D local gamma index (GI) analysis using 3% for dose difference and 2mm for distance to agreement passing criteria and a low-dose cut-off threshold of 30%.

Results: Good agreement between measured and TPS calculated dose distributions with GI passing rates ≥ 92% was observed for all irradiations. The highest passing rates (up to 99.6%) were observed for the irradiations performed after 6D corrections, with the plan with two isocenters presenting better agreement compared to the plan with the single isocenter. The lowest passing rate (92%) was observed for the plan for which the maximum (3°) rotation was detected according to the CBCT and not corrected for (i.e. only translational corrections were applied).

Conclusions: Experimental validation showed that the best agreement between measured and TPS calculated dose distributions for multiple brain metastases cases, treated with SRS-VMAT