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In this issue

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I am pleased to introduce the 'In this issue' for the third issue of the Journal of Radiotherapy in Practice for Volume 18 published in September 2019. In this issue there are 11 original articles on a range of subjects, including several articles on the dosimetry of intensity-modulated radiotherapy (IMRT). The literature review in this issue is on the impact of exercise on treatment-related fatigue among patients receiving adjuvant radiotherapy for breast cancer. To complete this issue, there are two technical notes, both on the subject of the dosimetric analysis of volumetric arc therapy.

In the first article, Joyce, O'Boyle, McDermott and Small investigate the role of the tumour volume as a prognostic indicator in non-small cell lung cancer (NSCLC) patients treated with definitive radiotherapy. It has been shown that patients with a greater tumour volume have poorer outcomes following definitive radiotherapy but its exact role remains unclear.

In this study, 167 patients with NSCLC treated by definitive (chemo)radiotherapy were retrospectively reviewed between 2006 and 2015. Patient demographics, disease characteristics and tumour volume parameters were collected. Univariate analyses were carried out using Kaplan–Meier survival curves to assess the association of potential prognostic factors with the primary endpoints of overall survival rates and loco-regional recurrence rates. Multivariate analyses were carried out using a Cox regression method. The findings of the study indicate that the target tumour volume (TTV) is a significant prognostic factor in patients with advanced NSCLC treated by radical radiotherapy. In this cohort of patients, TTV is more reliable at predicting survival than target stage and overall stage.

In the next article, Agarwal, Rastogi, Das, Yoganathan, Udayakumar, Naresh and Kumar present their study on the evaluation of the dosimetric consequences of multileaf collimator (MLC) leaf positioning errors in dynamic IMRT treatments. The purpose of this study was to evaluate the dosimetric impact of MLC positional errors in dynamic IMRT treatments through planning simulation. Second, the sensitivity of IMRT MatriXX device for detecting the MLC leaf positional errors was also evaluated. Five dynamic IMRT plans, each for brain and head–neck (HN), were retrospectively included in this study. An in-house software was used to introduce random errors (uniform distribution between −2.0 and +2.0 mm) and systematic errors [± 0.5, ±0.75, ±1.0 and ±2.0 mm (+ : open MLC error and − : close MLC error)]. The error-introduced MLC files were imported into the treatment planning system (TPS) and new dose distributions were calculated. The error-introduced plans were delivered on a linear accelerator and the planar fluences were measured by IMRT MatriXX. 3%/3 mm and 2%/2 mm γ-criteria were used for analysis.

It is concluded that the acceptable systematic error was 0.4 mm for brain and 0.3 mm for HN. Furthermore, IMRT MatriXX device was able to detect the MLC errors ≥2 mm in HN and 3 mm errors in brain with 2%/2 mm γ-criteria.

In the article by Banaei, Hashemi, Bakhshandeh and Mofid, the aim of the study was to quantify the relationship between the planning target volume (PTV) dose homogeneity and organs at risk (OARs) sparing in correlation with anatomical parameters in prostate IMRT. Nine IMRT plans with various target dose constraints' priorities were created for 15 prostate cancer patients. Selected PTV and OARs parameters were calculated for the patients. A trade-off was assessed between homogeneity index (HI) and OAR sparing. Several anatomical parameters were evaluated to investigate their effects on the OAR sparing and HI. The findings indicate that enforcement of target dose constraints was more effective on the improvement of HIs for the patients with initial high HI values at low dose constraints' priorities. Reducing the priority had more effects on the OARs sparing compared to HI, especially for the patients with high OAR doses in high priority plans. This can be attributed to smaller distances or greater joint volumes between the OARs and PTV.

The purpose of the study by Rehman, meanwhile, was the verification of IMRT HN treatment planning with a one-dimensional and two-dimensional (2D) dosimeter using Imaging and Radiation Oncology Core Houston (IROC-H) head & neck (H&N) phantom. The image of the H&N phantom was obtained by a computed tomography (CT) scan, which was then transferred to Pinnacle@3 TPS (version 9.4) for treatment planning. The contouring of the target volume and critical organs was done manually and dose constraints were set for each organ according to IROC prescription. The plane was optimised by adoptive convolution algorithm to meet the IROC criteria and the collapse cone convolution algorithm calculated the delivered dose for treatment. The planned treatment was delivered to the phantom three times through a Varian Clinac 2110 for reproducibility. The treatment plan was verified by measuring the doses from thermo-luminescent dosimeters (TLDs) and films. The agreement between the planned and delivered doses was checked by calculating their percentage differences and analysing their isodose line profiles and 2D γ maps.

In conclusion, IMRT pre-treatment validation can be done with IROC anthropomorphic phantoms, which is essential for the delivery of modulated radiotherapies. It was concluded that film and TLDs would be used for quality assurance (QA) tools for IMRT.

In the next article, Zulkafal, Iqbal, Akhtar, Iqbal and Khan present their evaluation of 3D conformal radiation therapy of oesophageal cancer. The main objective of their research was to compare the dosimetric effect on lower and upper oesophagus cancer treatment using 3D conformal radiotherapy (CRT) as well as to evaluate the doses administered to the OARs. A cohort of 30 oesophageal cancer patients between the ages of 45 and 67 years registered during March 2017 to February 2018 was considered. These patients were treated through 3D-CRT using four-field technique. Beam energy of 15 MV from Varian DHX linear accelerator was used. The first group of 15 patients with upper oesophagus cancer was prescribed 5000 cGy doses, and the second group of remaining 15 patients with lower oesophagus cancer was prescribed 4500 cGy. CT scans of every patient were obtained and then transmitted to Eclipse TPS for generating treatment plans. Uniformity index (UI) calculated for first group of patients showed difference of 7·4% from ideal value. A difference of 7% between ideal and calculated UI value was observed in second group of patients. The values of other dosimetric indices like coverage, homogeneity, moderate dose homogeneity index (mDHI) and radical dose homogeneity index (rDHI) were found in limits specified by the Radiation Therapy and Oncology Group. The maximum difference of 6% was observed between the coverage mean values of first and second group treatment plans. In conclusion, for oesophageal cancer, 3D-CRT using four-field treatment plans shows homogeneous distribution of dose around the target and limits the dose to OAR.

In the next article, Slassi, Ouabi and El Khayati present their study on the comparison of an in-house developed monitor unit (MU) double-check program for comparing 3D-CRT and TPS verification. The TPS plays a key role in radiotherapy treatments; it is responsible for the accurate determination of the MU needed to be delivered to treat a patient with cancer. The TPS has a QA tool, an independent program that double-checks the MU, evaluates patient plan correctness and searches for any potential error. A comparison was carried out between the MU calculated by the TPS and an independent in-house developed Monitor Unit Calculation Program (MUCP). The program, written in Cplusplus (C++ Object Oriented), requires a database of several measured quantities and uses a recently developed physically based method for field equivalence calculation. The ROOT CERN data analysis library has been used to establish fit functions, to extend the MUCP use for a variety of photon beams. The findings were that the MUCP is a useful tool for basic and complex MU verification for 3D-CRT plans.

In the article by Thiyagarajan, Nambiraj, Manigandan, Karrthick, Singaravelu, Selvaraj and Kataria, the authors investigate the fraction-specific post-treatment QA for active breath-hold (ABC) radiation therapy. This study attempts to evaluate variation in the treatment beam-hold pattern and quantify its dosimetric impact in breath-hold radiotherapy using fraction-specific post-treatment QA. A patient with lung metastasis treated using IMRT with ABC was used in this study. Treatment beam-hold conditions were recorded for all the 25 fractions. Linearity and reproducibility of dosimetric system were measured. Variation in the dose output of unmodulated open beam with beam hold was studied. Patient-specific QA was performed with and without beam hold and the results were compared to quantify the dosimetric impact of beam hold. The authors conclude that patient comfort with the ABC system and responsiveness to the therapist communication helps to maintain a consistent breathing pattern and in turn consistent treatment delivery pattern. However, the magnitude of the dosimetric error is much less than the acceptable limits recommended by imaging and radiation oncology core. The dosimetric error induced by the beam hold is over and above the dose difference observed in conventional patient-specific QA.

The next article is on the subject of a hybrid approach for HN cancer using online image guidance and offline adaptive radiotherapy planning. The authors, Srivastava, Sharm, Das and Manjhi, present their prospective study to evaluate the dosimetric benefits of treatment plan adaptation for patients who had undergone repeat computed tomography (ReCT) and re-planning due to treatment-induced anatomical changes during radiotherapy. This study involved five HN cancer patients who had their treatment plan modified, based on a weekly thrice imaging protocol. Impact of mid-course imaging was assessed in patients, using ReCT and cone beam computed tomography (CBCT)-based dose verification, respectively. Patients were imaged, apart from their initial CT, during the course of their radiation therapy with a ReCT and on-board imager (OBI) CBCT. Each CBCT/CT series was rigidly registered to the initial CT in the TPS Eclipse, using bony landmarks. The structures were copied to the current CBCT/CT series and, where needed, manually edited slicewise. The dose distribution from the treatment plan was viewed as of the current anatomy by applying the treatment plan the CBCT/CT-series, and studying the corresponding dose–volume histograms for OAR doses. The findings indicate that the CBCT is a useful tool to view anatomic changes in patients and to get an estimate of their impact on dose distribution. Re-planning based on imaging in HN patients during the course of radiotherapy is mandatory to reduce side effects.

In the article by Tuğrul, Olacak and Köylü, the aim of the study is to compare 3D-CRT, IMRT and tomotherapy techniques used in the treatment of prostate cancer with target and critical organ doses to be included. The target dose was studied with 4- and 6-field 3D-CRT, 7-field IMRT and tomotherapy techniques used to treat prostate cancer and the dose–volume histogram of critical organs was analysed. The same target volumes and critical organs doses described for the three techniques were compared. A total dose of 76 Gy was given using 6 and 18 MV for 3D-CRT, 6 MV for IMRT and tomotherapy techniques. The findings were that critical organs are better protected by the tomotherapy technique. However, the minimum doses that healthy tissue received was higher in the tomotherapy technique.

In the article by Bencheikh, Maghnouj and Tajmouati, the authors present their study to introduce a new approach to assess the dosimetry quality of the photon beam with energy and irradiation field size. This approach is based on percentage depth dose fragmentation for investigating the dosimetry quality. For the investigation of the dosimetry quality for 6 and 18 MV photon beams, the authors have proceeded to fragment the percentage depth dose at different field sizes. This approach introduces the overall percentage depth dose for checking and is not restricted to the exponential decay regions, as the International Atomic Energy Agency Technical Reports Series No 398 and the American Association of Physicist in Medicine Task Group 51 recommend. The findings were that the dose measured at different points of

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the beam is higher for 6 MV than for 18 MV photon beam. Therefore, the 6 MV beam is more dosimetric efficient than the 18 MV beam. Based on this approach, the authors were able to assess the dosimetry quality by taking into account the overall percentage depth dose in the field and not only in the exponential decay region.

In the next article by Jayamani, Osman, Tajuddin, Salehi, Ali, Zahri and Aziz, the aim was to examine the effect of bit depth on CT number for high-density materials. Analysis of the CT number for high-density materials using 16-bit scanners will extend the CT scale that currently exists for 12-bit scanners and thus will be beneficial for use in CT–electron density (ED) curve in radiotherapy TPS. Implementation of this extended CT scale will compensate for tissue heterogeneity during CT–ED conversion in treatment planning. An in-house built phantom with 10 different metal samples was scanned using 80, 100 and 120 kVp in two different CT scanners. A region of interest was set at the centre of the material and the mean CT numbers together with data deviation were determined. Dosimetry calculation was performed by applying a direct anterior beam on 12-bit, 12-bit extended and 16-bit. The findings of the study were that high-density materials require 16-bit scanners to obtain the CT number to be implemented in treatment planning in radiotherapy. This also suggests that proper tube voltage together with correct CT–ED resulted in accurate TPS algorithm calculation.

The next paper is a literature review on the impact of exercise on treatment-related fatigue among patients receiving adjuvant radiotherapy for breast cancer. Authors McNally, Shepherd and Flood evaluate the use of exercise in managing fatigue in breast cancer patients undergoing adjuvant radiotherapy. To explore the effectiveness of different exercise practices and explore how optimum management of fatigue might be achieved, a CINAHL database search of literature was undertaken and publications screened for retrieval with 24 qualifying for inclusion in the review. The findings are exercise that is considered a safe, non-pharmacological intervention for early-stage breast cancer patients receiving adjuvant radiotherapy. Further investigation is required into optimum exercise interventions and the effectiveness and viability of supervised and unsupervised models. Patient-centred tailored advice and guidance needs to be developed and effectively promoted by therapeutic radiographers in order for patients to fully realise the benefit.

In the first of two technical notes presented in this issue, authors Olmos, Rodriguez, Beltran, Garay, Felix, Ponce, Salcedo, Garcia, Llo, Guzman and Chilaca undertake a dosimetric comparison of whole abdominal treatment plans of patients diagnosed with stage 3 Wilms tumour in order to assess the benefits of treating these patients with volumetric arch therapy (VMAT) versus 3D-CRT. A retrospective study was undertaken on 23 patients receiving either VMAT or 3D-CRT during 2013 to 2017. A dosimetric comparison was undertaken for both techniques for doses to the PTV, using the conformity index and homogeneity index and to OARs. This work advocates using the VMAT technique in whole abdominal irradiation to improve conformity, without affecting the quality of the PTV coverage, when compared with the 3D conformal technique. In addition, VMAT reduces the doses to OAR such as the remaining kidney and lungs that are important to preserve to reduce the probability of radiation toxicity in these patients.

The final article is a technical note by authors Rehman and Hussain, who studied the verification of dose delivery and quality assurance of VMAT for HN cancer. The IROC-H H&N phantom with TLDs and films were imaged with a CT scan and the reconstructed image was transferred to pinnacle TPS. On the TPS the PTV, secondary target volume and OARs were delineated manually and a treatment plan was produced. The dose constraints were determined for the concerned organs according to IROC-H prescription. The treatment plan was optimised using adoptive convolution algorithm to improve dose homogeneity and conformity. The dose calculation was performed using C.C convolution algorithm, and a Varian True Beam linear accelerator was used to deliver the treatment plan to the H&N phantom. The delivered radiation dose to the phantom was measured through TLDs and GafChromic EBT2 films. The dosimetric performance of the VMAT delivery was studied by analysing percent dose difference, isodose line profile and γ analysis of the TPS computed dose and linac delivered doses. The conclusions were that the dosimetric performance of VMAT delivery for a challenging H&N radiotherapy can be verified using TLDs and films imbedded in an anthropomorphic H&N phantom.

Professor Angela Duxbury