Editorial - Educational

Future of the Radiation Therapy Treatments in Bahrain

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In March of 2018, the new Radiation Oncology Department of the King Hamad Oncology Center opened its doors for the first patient treatment. In the past decade, the technological advances in radiation therapy were the driving force for the success of radiation oncology. The Oncology Center at King Hamad University Hospital has been equipped with the latest developments in the field of radiation oncology.

Studies performed in the regions with high and limited access to radiation therapy demonstrated that optimally 52% of all cancer cases should receive radiation treatment as part of their therapy[1,2]. The success of radiation therapy for the treatment of most common cancers either alone or as adjuvant therapy was practiced during the past three decades, and it is strongly associated with the technological developments in the field.

Since the 1990s, the development of the multi-leaf collimators (MLC) led to the success of 3D conformal radiation therapy (3D-CRT); in which irradiated tumor volume and treatment dose distribution are reconstructed on CT images, and the fields are shaped according to the projections of the tumor. The technology was strongly supported by the advances in CT-imaging technology and the availability of dedicated CT scanners to the radiation therapy services. The use of 3D-CRT changed the clinical outcomes for prostate cancer patients[3,4]. The conformal treatment fields made dose escalation possible; therefore, improvement of biochemical outcomes and treatment toxicity of the bladder and rectum were significantly reduced.

Digital linear accelerators, high-resolution collimators and treatment software with the implementation of the inverse optimization algorithms were the main contributors to the intensity-modulated radiation therapy (IMRT). In this treatment technique, superposition of multiple treatment fields, created in static or dynamic mode, allows changing the radiation fluence map and consecutively shaping the high dose area to the concave shapes of the target volumes with avoidance of the critical organs. From the specialized treatment technique available in few centers worldwide, IMRT became a well-acknowledged technique with proven clinical outcomes for head and neck, gynecologic and prostate cancers[5-7]. In head and neck carcinomas, the use of IMRT reduces the rate of xerostomia, while simultaneously allows dose escalation within the tolerance of the spinal cord, optic pathways and brainstem[8,9]. The benefits of IMRT were confirmed and explored further with the introduction of the volumetric modulated arc therapy (VMAT). Besides the obvious advantage of faster treatment sessions, which reduce costs and increase the capacity of radiation therapy departments, the treatment technique allowed an additional degree of freedom in the treatment plan.

The accuracy of the delivery was investigated during the past decade, from the dosimetric point of view, clinical and geometric accuracy of the treatment delivery. The dosimetric accuracy of treatment delivery was significantly improved with the capacity of the treatment planning software to incorporate the Monte Carlo algorithm for dose calculation and development of advanced radiation detectors for the patient-specific quality assurance[10]. Target delineation became the focus of multiple publications and guidelines in radiation oncology. A novel approaches with the involvement of the PET-CT imaging and/or automated target delineation were investigated[11-14]. The geometric accuracy of delivery was focused on the equipment vendors and commercial availability of in-room imaging devices (such as CT-on rails, megavoltage (MV) and kilovoltage (kV) imaging devices mounted on the linear accelerator). This facilitates comparison of the clinical outcome and emphasized the importance of image-guided radiation therapy (IGRT) for treatments. IGRT techniques with the acquisition of cone-beam CT volumetric images on the treatment couch account for inter-fraction patient setup uncertainties, patient volume changes due to weight loss and tumor volume reduction during radiation therapy. Additionally, tumor movements due to breathing could be evaluated and controlled with kv-CBCT technology[15].

All technological advances described above have made the accurate treatments on the linear accelerator possible. Clinical data are available for the benefits of hypofractionated treatments of small primary tumors and metastatic disease. Stereotactic body radiation therapy (SBRT) and stereotactic radiosurgery, due to the ablative nature of the high fractional doses, demonstrated excellent local control for T1-T2 tumors in non-small cell lung cancer, hepatic metastasis and brain tumors[16-18].

Current focal point in radiation therapy is shifting towards the investigations of the interactions between radiation therapy and systemic treatments given to cancer patients. Some data are available about the combined action of radiation therapy with

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bevacizumab revealing an increased tumor sensitivity to radiation[19]. Combination of the SBRT with immunotherapy is especially interesting due to the abscopal effect of the increased immune response after a high dose radiation treatment[20]. If further clinical trials confirm the pre-clinical investigations, it will open a wide range of indications for SBRT treatments in multiple tumor sites.

The new Radiation Oncology department in King Hamad Oncology Center is designed to provide all types of services in radiation therapy for the patients, such as conventional radiation therapy, high-precision intensity-modulated techniques with image guidance, stereotactic hypo-fractionated treatments for cranial and extra-cranial tumor locations, intracavitary and interstitial brachytherapy applications. The department is equipped with a dedicated wide bore CT simulator (Siemens Somatom) for the preparation of patient images for treatment planning and imaging with patient-specific immobilization devices in place.

The main patient load is expected to be on two linear accelerators with daily capacity to deliver above 40 treatment sessions per day on each machine. Both machines have the last generation high-speed multi-leaf collimators with 160 leaves of 5 mm to form high-definition treatment fields in 3D conformal, intensity-modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT). Synergy Platform, Elekta would be dedicated to for the majority of breast cancer cases under the megavoltage image guidance and respiratory gating (to minimize the exposure of the healthy lung tissue and heart). The second linear accelerator would take most of the complex cases for lung, colorectal, advanced prostate and head-and-neck cancers. Elekta's Versa HD is one of the very few currently available in the Gulf region for SBRT treatments. Such treatment machine has been available in Jeddah, KSA for the last two years and soon, another would be operational at King Faisal Specialist Hospital & Research Centre (KFSH & RC, Riyadh).

The linear accelerator has a distinct feature called flattening filter free (FFF) beams, which enable quick treatment delivery for the hypofractionated treatments with high fractional doses above 7 Gy. Those beams have much higher dose rate, compared to the conventionally used photon energies and deliver therapeutic radiation dose much faster. Speed in the treatment delivery and shorter treatment sessions, minimize the uncertainty in the delivery of the dose to the moving targets such as lung tumors, bladder or prostate. Another advantage of the FFF beams is lower dose burden outside the field, which is important for the young and pediatric patients as it can decrease the risk of the secondary radiation-induced malignancies. The IT infrastructure of the department includes several advanced contouring workstations with capability of tumor delineation on CT, MR and PET-CT images and automatic segmentation software for the critical organs.

Dedicated oncology information system supports the data and image flow in the department for the increased efficacy of the treatment process. The new department is promising to take a strong position at the King Hamad Oncology Center because of the available technological equipment and implementation of the modern treatment techniques.

Together with opportunities to perform IMRT, VMAT and stereotactic body radiation therapy, we are looking forward to better future for radiation therapy in Bahrain and better availability of advanced radiation therapy services for the population.

Potential Conflicts of Interest: None.

Competing Interest: None.

Sponsorship: None.

Acceptance Date: 5 May 2018.

Ethical Approval: Approved by the King Hamad Oncology Center, Bahrain.

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