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The Rapid Arc Radiation Therapy Technology's Clinical Utility

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Abstract:
Rapid Arc TM is a radiation technique that uses the linear accelerator gantry's full 360° rotation and speed variation to deliver highly conformal dose distributions. When compared to traditional radiationtechniques, this method—known as volumetric modulated arc therapy, or VMAT—can achieve high-target volume coverage while sparing damage to normal tissues. In a brief amount of time, usually a few minutes, RapidArc provides image-guided radiation therapy with precise dose distribution and conformity that is on par with or better than intensity-modulated radiation therapy. The RapidArc technology is currently being utilized in numerous centers to treat a high volume of patients. It is used by both large and small hospitals to treat the most difficult cases, but it is also being used more and more for common cancers.

Keywords: Radiation Therapy, IMRT, VMAT, SBRT, SRS,Treatment Planning Software, Rapidarc .

Introduction

Rapid Arc, a novel arc delivery method, has been introduced to the market by Varian Medical Systems, Inc. (Palo Alto, CA, USA). Using this technique, the treatment is administered during one or more arc rotations of the linac gantry. During this rotation, the dose rate is adjusted in tandem with the dynamic movement of the multileafcollimators (MLCs) due to variations in the gantry speed rotation.

When Yu et al. first described intensity-modulated arc therapy (IMAT)in 19952, it was necessary to employ multiple superimposed arcs in order to achieve a satisfactory dose distribution (LoSasso , 2001).

According to Yu et al., the overall IMAT concept uses multiple arcs thatare all delivered in a cone-beam manner, but using a "arc-in-arc" technique (Palma , 2008).

The RapidArc method can be viewed as an expansion of dynamic MLC IMRT, and the RapidArc-specific combination of dose rate variations and gantry rotation with variable speed, as well as machinecommissioning and quality assurance, should be validated (Clivio ,2009).

Clinical applications of RapidArc :

RapidArc has been used to treat metastases and brain cancers. For brain gliomas, Davidson et al. identified the benefits of VMAT over IMRT and assessed the impact of both full and partial arcs using the VMAT technique. The researchers concluded that VMAT provides faster delivery than IMRT for brain tumors while

maintaining a very similar dosimetric effect to IMRT plans. They also observed a reduction in the integral dose using an additional partial arc and foundparticular benefit in relation to IMRT with regard to spinal cord sparing.A planning study of 12 patients using RapidArc, fixed-field IMRT with five to seven fields, and helical tomotherapy was investigated in a study by (Fogliata et al. 2012). The patients had pituitary adenomas, acoustic neuromas, and meningiomas.

Cancer of the head and neck :

Because head and neck cancers are typically located close to vital organs where limiting dose irradiation is required, radiation therapy forthese types of tumors can present challenges due to the anatomy of this area. Furthermore, because of the abundant lymphatic supply in the head and neck region, these cancers frequently have an aggressivephenotype, grow quickly, and may manifest at a locally advanced stage.Because it provides an alternative to surgical resection, which may result in unacceptable cosmetic deformity and functional impairment, radiotherapy is a crucial treatment modality for these tumors. Clinical cases of head and neck cancers are usually treated using the standardIMRT technique. This was the most effective way to protect OARs thatwere close to the tumor volume until recently. (Bertelsen et al., 2010) replanned 25 patients with hypopharyngeal or oropharyngeal tumors treated with IMRT using one-arc VMAT.

In head and neck radiotherapy, the target volumes are especially intricate. Based on the aforementioned observations, it appears evidentthat multiple arcs are required to attain an acceptable dose distribution(Johnston et al., 2011).

Lung cancer:

When it comes to dosimetric parameters and normal tissue sparing, there is still opportunity for improvement in the lung cancer treatmentprocess with the switch from 3D-CRT to IMRT. Radiation treatment planning and dose delivery are significantly impacted by geometric and dosimetric uncertainties resulting from intrafraction motion. The tumor positions during the respiratory cycle can be visualized using avariety of techniques, including respiratory gating, active breathing coordinator, deep inspiration breath-hold techniques, respiratory gating, and four-dimensional CT scanning. The optimization of the dose distribution to a moving target is now possible thanks to the combination of RapidArc and dynamic MLC tracking. A dynamic multi-leaf collimator algorithm linked to tracking target motion for arc therapyproduced encouraging results in a recent feasibility study (Zimmerman, 2009).

Gynecological cancer :

The application of Arc techniques has attracted attention and interestin the radiation treatment of other pelvic malignancies and gynecological cancers because RapidArc treatment for prostate cancer has produced a positive dosimetric response.

Prostate cancer:

For a very long time, IMRT has been the accepted method for primaryprostate radiotherapy in a number of institutions. After arc therapy wasintroduced, the switch from IMRT to VMAT methods happened quickly. Because of the anatomy of this type of anatomical district, VMAT may be the best treatment for prostate cancer. The study conducted by (Palma et al., 2008) looked at 3D-CRT, IMRT, and VMAT in relation to localized prostate cancer. When considering all dosimetric parameters, IMRT and VMAT techniques resulted

in superior critical organ sparing when compared to 3D conformal plans.

Other tumors:

Rapid Arc has been used to treat tumors in a number of different bodyparts, including breast cancer, pancreatic cancer, and total-marrow radiation. It was a common finding in these studies that RapidArc offered significant added value in treatment planning and dose conformance, but it was more effective at delivering doses. These studies highlight the possibility of using VMAT and RapidArc techniques as an alternative to conventional irradiation techniques forthe treatment of various cancers (Hoogeman , 2008).

Recommendations:

While RapidArc plays a significant and expanding role in the treatmentof various tumors, it is not a panacea for all clinical situations. Every clinical case needs to be assessed separately in order to determine which radiation treatment will produce the best results.

An advantage of VMAT with RapidArc over previous irradiation techniques like helical tomotherapy, IMAT, or IMRT is the ability to distribute the dose throughout the entire volume, rather than just a portion of it. Furthermore, the treatment planning algorithm ensures excellent healthy-tissue sparing and highly accurate dose delivery.

Conclusion:

The majority of published literature involves dosimetric planning data, with only a small number of studies pertaining to clinical outcome data. However, since VMAT is a new technology, more patients are being treated, and more clinical data will be gathered. The majority of dosimetric studies compared VMAT with fixed-field IMRT and 3D-CRTtechniques for different tumor sites.

Since VMAT is a development of IMRT, the similarities between IMRT and VMAT are not surprising. As the reviewed studies havedemonstrated, the main distinction is the notable decrease in delivery time and MUs in favor of VMAT. It is challenging to compare results from different studies because of significant differences in target volume definitions, dose prescriptions, and administered doses. Moreover, thenumber of fields or arcs and the gantry angles in IMRT and VMAT mayvary; as a result, the data on target coverage and healthy-organ sparingmay vary significantly between studies.

While RapidArc plays a significant and expanding role in the treatmentof various tumors, it is not a panacea for all clinical situations. Every clinical case needs to be assessed separately in order to determine which radiation treatment will produce the best results.

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