REPORTS OF PRACTICAL ONCOLOGY AND RADIOTHERAPY 18 (2013) 383–386

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: http://www.elsevier.com/locate/rpor

Review

Volumetric-modulated arc therapy with RapidArc®: An evaluation of treatment delivery efficiency

Beatriz E. Amendola[*,1], *Marco Amendola*[2], *Naipy Perez*[3], *Alejandro Iglesias*[4], *Xiaodong Wu*[5]

Innovative Cancer Institute, 6141 Sunset Drive, Suite 102, South Miami, FL 33143, USA

ARTICLE INFO

Article history:
Received 30 April 2013
Accepted 8 July 2013

Keywords:
IMRT
RapidArc
VMAT
SBRT
SRS
Treatment Planning software

ABSTRACT

Aim/background: To evaluate how the use of volumetric-modulated arc therapy (VMAT) with RapidArc® can improve treatment delivery efficiency based on the analysis of the beam-on times and monitor units (MU) needed to deliver therapy for multiple clinical applications in a large patient population.

Materials and methods: A total of 898 treatment courses were delivered in 745 patients treated from October 2008 to March 2013 using RapidArc® treatment plans generated in Eclipse™ TPS. All patients were treated with curative or palliative intent using different techniques including conventional fractionation (83%) and radiosurgery or SBRT (17%), depending on the clinical indications. Treatment delivery was evaluated based on measured beam-on time and recorded MU values delivered on a Varian Trilogy™ linear accelerator.

Results: For conventional fractionation treatments using RapidArc®, the delivery times ranged from 38 s to 4 min and 40 s (average 2 min and 6 s). For radiosurgical treatments the delivery times ranged from 1 min and 42 s to 9 min and 22 s (average 4 min and 4 s). The average number of MU per Gy was 301 for the entire group, with 285 for the conventional group and 317 for the radiosurgical group.

Conclusions: In this study with a large heterogeneous population, treatments using RapidArc® were delivered with substantially less beam-on time and fewer MUs than conventional fractionation. This was highly advantageous, increasing flexibility of the scheduling allowing treatment of radiosurgery patients during the regular daily work schedule. Additionally, reduction of leakage radiation dose was achieved.

* *Corresponding author*. Tel.: +1 305 669 6833; fax: +1 305 666 4030.
E-mail addresses: dramendola@gmail.com, dramendola@bellsouth.net (B.E. Amendola).

[1] Study design, data collection, data interpretation, manuscript preparation, and literature search.
[2] Study design, data interpretation, manuscript preparation, and literature search.
[3] Data collection, statistical analysis, data interpretation, manuscript preparation, and literature search.
[4] Study design and data collection.
[5] [5]Study design, statistical analysis, data interpretation, and literature search.

1507-1367/$ – see front matter © 2013 Greater Poland Cancer Centre. Published by Elsevier Urban & Partner Sp. z o.o. All rights reserved.
http://dx.doi.org/10.1016/j.rpor.2013.07.005

1. Introduction

1.1. Background

RapidArc® (Varian Medical Systems, Palo Alto, CA) is a novel technique developed to deliver highly focused volumetric-modulated arc therapy[6] approved for clinical use in 2008 [1]. The basic concept of arc therapy is the delivery of radiation from a continuous rotation of the radiation source. In the case of RapidArc® it delivers a precisely sculpted 3D dose distribution with a 360° rotation of the accelerator gantry made possible by a treatment planning algorithm that varies simultaneously 3 parameters during treatment: (1) gantry rotation speed, (2) treatment aperture shape using the movement of multileaf collimator leaves and (3) delivery dose rate [2]. This technique can achieve highly conformal dose distributions with improved target volume coverage and sparing of normal tissues compared with conventional radiotherapy techniques. In addition, it also has the potential to offer reduced treatment delivery time and less MUs compared with conventional static field intensity modulated radiotherapy.[7]

In the case of radiosurgery, delivery of high-dose-per-fraction SRS or SBRT with multi-field IMRT can be highly time-consuming because of the many beam angles required to conform to the target shape and the large number of monitor units[8] needed to deliver the dose [3].

In this retrospective review we analyze the beam-on times and MU per fraction needed to deliver therapy with RapidArc® at several sites in a large patient population of multiple clinical applications including conventional fractionation and radiosurgery/SBRT.

2. Materials and methods

From October 2008 to March 2013 a total of 745 patients received 898 treatment courses using RapidArc®: 749 (83%) with conventional fractionation and 149 (17%) with radiosurgery/SBRT. Diagnosis and treatment sites characteristics are shown in Table 1. For conventional RapidArc® the number of arcs ranged from 1 to 5, but most frequently 2 arcs were used. For RapidArc® Radiosurgery/SBRT the number of arcs ranged from 2 to 6 depending on the size, location, and volume of the target. Partial arcs and multiple coplanar/non-coplanar arcs were used depending on the case specification (see Table 2).

Patient specific quality assurance[9] was performed prior to first day of treatment delivery using a XWU-IMRT Phantom (Best Medical Canada Ltd.) with MOSFETS and film dosimetry and/or the ArcCHECK® System (Sun Nuclear Corporation). Dose agreement was within 3%.

Patients were selected for RapidArc® following the same indications as conventional IMRT: anytime that critical structure protection required the creation of complex dose distributions; if the target volume was irregularly shaped and in close proximity to critical structures that needed to be protected, the volume of interest was covered with narrow margins to adequately protect immediately adjacent structures; an immediately adjacent area that had been previously irradiated and abutting portals were established with high precision in all cases of salvage radiation. Several fractionation schemes were used depending on the indications. One, 3, or 5 fractions were delivered in radiosurgery/SBRT, and anywhere from 15 to 45 daily fractions for conventional regimens. In general for conventional treatments, shorter schemes where used for palliative cases and longer ones for curative intent.

Table 1 – Total number of RapidArc® treatment courses/site.

Site/diagnosis	No. treatment courses
Prostate	156
Gynecological	137
Lung	106
H/N	91
Spine	87
Pelvis	87
Brain	60
Abdomen	58
Chest	19
Breast	18
Liver	18
Rectum	17
Skin	15
Bladder	11
Pancreas	10
Esophagus	8
Total	898

Table 2 – Range and average values of beam-on time for conventional fractionation and SRS/SBRT using RapidArc®.

Beam-on time	Conventional	SRS/SBRT
Min	0.63	1.7
Max	4.68	9.36
Average	2.08	4.06

All patients were treated using a Trilogy™ Linear accelerator (Varian Medical Systems, Palo Alto, CA) with energies of 6 or 16 MV and a 120 multi-leaf collimator, planned with Eclipse™ system using inverse treatment planning. Cone Beam CT (CBCT)[10] was used daily for image guidance before delivering the treatment.

For treatment planning, CT simulation was acquired with various immobilization devices including customized Aquaplast and *body*-frame. For head and neck, thoracic and CNS tumors IV contrast was routinely used to aid tumor delineation unless contraindicated. The gross and/or clinical tumor volume[11,12] were defined using CT, MRI, and/or PET/CT. MRI was used in most CNS and in GYN patients unless contraindicated. PET/CT was generally used, particularly for lung and

[6] Volumetric-modulated arc therapy (VMAT).
[7] Intensity modulated radiotherapy (IMRT).
[8] Monitor unit (MU).
[9] Quality assurance (QA).
[10] Cone Beam CT (CBCT).
[11] Gross tumor volume (GTV).
[12] Clinical tumor volume (CTV).