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Dosimetric influence of photon beam energy and number of arcs on volumetric modulated arc therapy in carcinoma cervix: A planning study

Girigesh Yadav, Manindra Bhushan, Abhinav Dewan, Upasna Saxena, Lalit Kumar, Deepika Chauhan, Kothanda Raman, Swarupa Mitra, Mahammood Suhail*

Division of Medical Physics & Department of Radiation Oncology, Rajiv Gandhi Cancer Institute and Research Centre, Sector-5, Rohini, New Delhi 110085, India

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ABSTRACT

Aim: Aim of the present study was to compare the dosimetric impact of different photon beam energies and number of arcs in the treatment of carcinoma cervix.

Background: Carcinoma cervix is a common cancer in women worldwide with a high morbidity rate. Radiotherapy is used to treat such tumours. Volumetric Modulated Arc Therapy (VMAT) is considered superior to other techniques with multiple arcs and energies.

Materials and methods: Twenty patients with carcinoma cervix underwent radiotherapy in a prospective observation study conducted at our institute. Volumetric modulated arc plans with 6 MV, 10 MV and 15 MV photon energies using single arc (SA) and dual arc (DA) were generated. Several physical indices for planning target volume (PTV) like $V_{95\%}$, $V_{100\%}$, $V_{110\%}$, $D_{98\%}$, $D_{50\%}$, $D_{2\%}$ and total number of MUs were compared. Normal Tissue Integral Dose (NTID) and dose to a shell structure $PHY_{2.5}$ and $PHY_{5.0}$ were analyzed.

Results: Comparable dose coverage to PTV was observed for all the energies and arcs. CI for DA_{6MV} (1.095) was better than SA_{6MV} (1.127), SA_{10MV} (1.116) and SA_{15MV} (1.116). Evaluated parameters showed significant reduction in OAR doses. Mean bladder dose for DA_{6MV} (41.90 Gy) was better than SA_{6MV} (42.48 Gy), SA_{10MV} (42.08 Gy) and SA_{15MV} (41.93 Gy). Similarly, *p*-value for the mean rectal dose calculated was 0.001 ($SA_{6\text{ vs }15}$), 0.013 ($DA_{6\text{ vs }10}$) and 0.003 ($DA_{6\text{ vs }15}$) and subsequently favoured DA_{6MV}. Difference in NTID was very small.

Conclusions: The study showed no greater advantage of higher energy, and DA VMAT plan with 6 MV photon energy was a good choice of treatment for carcinoma cervix as it delivered a highly homogeneous and conformal plan with superior target coverage and better OAR sparing.

* *Corresponding author*. Fax: +91 11 27051037.
E-mail address: manindra.drp44@gmail.com (M. Bhushan).

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1. Background

Carcinoma cervix is the fourth most common cancer in women worldwide, with an estimated 5,300,000 new cases resulting in 7.5% of all female cancer deaths. Around 85% of the estimated deaths occur in developing countries from cervical cancer every year. The high mortality rate from cervical cancer globally (around 52%) could be reduced by effective screening and treatment programmes.[1] Morbidity rate was very high either due to disease progression or due to complications of the treatment until a few years back. But advancement in technology has helped a lot in curing these patients by delivering adequate dose to tumour and lesser dose to critical surrounding structures, leading to minimal complications during and after treatment.

Historically, a conventional technique using high photon energy with AP/PA fields or box technique was used for treatment of carcinoma of the cervix.[2] It was observed that the conventional technique delivered unnecessary doses to nearby critical organs, thereby leading to treatment related complications which was a big issue considering the high rate of cure and survival of disease. This was a problem we had to accept to cure the disease (Figs. 1–3).

Conventional modalities have given way to Intensity Modulated Radiation Therapy (IMRT) for the past two decades and most recently, we have seen the emergence of Volumetric Modulated Arc Therapy (VMAT) in which the treatment is delivered using partial or full arcs. IMRT uses fluence modulation and provides clinical and dosimetric benefits over the conventional technique. However, there is an increase in total monitor units (TMUs) with IMRT leading to increased risk of secondary cancers[3,4] known as radiation induced malignancies. Due to the movement of different machine parameters, VMAT manages to provide equivalent dose distribution with lesser monitor units and treatment time.[5]

In VMAT, radiation remains 'ON' even as the gantry rotates, MLCs shift and the dose rate varies, which translates into faster treatment. It also claims a higher degree of conformity of the intensity modulation which is proven to spare more of normal tissues.[6,7]

VMAT has received massive interest from the radiation therapy community as it was capable of delivering a highly conformal dose distribution within a short time interval. The clinical applicability of such new treatment techniques should be preceded by detailed dosimetric validation. Each arc creates its own impact on target coverage and sparing of nearby critical structures.[8]

2. Aim

This study was designed to compare the dosimetric effects of different photon beam energies in the treatment of carcinoma cervix. In addition to this, effect of the change in the number of arcs in accordance with beam energies to treat deep-seated tumours were also noted.

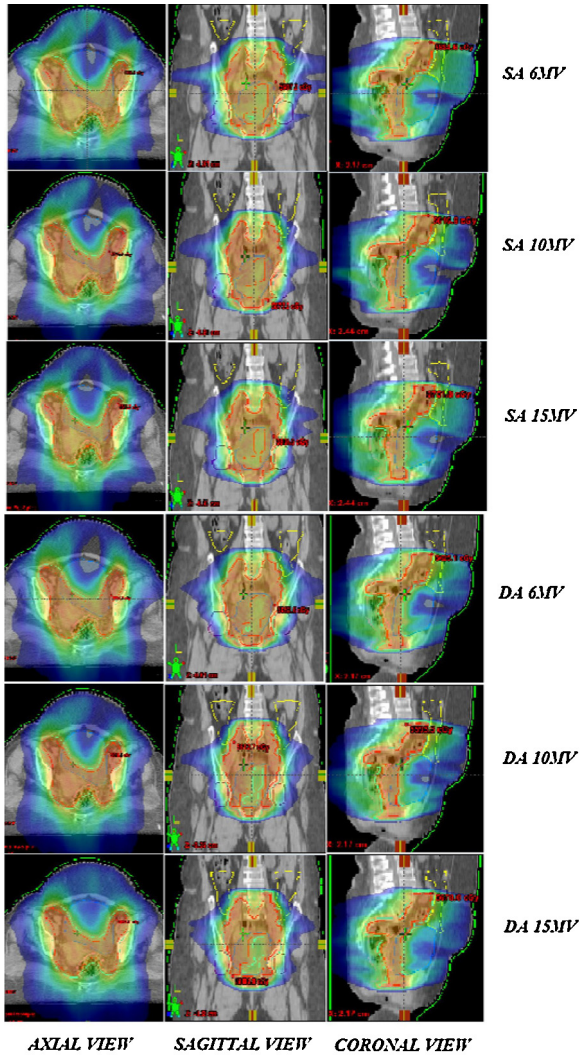

Fig. 1 – Spillage comparison (50% prescription dose) for different energy for SA and DA in different views.

3. Materials and methods

3.1. *Patient selection*

A cohort of 20 patients, diagnosed with carcinoma cervix were enrolled in this prospective observational study. Volumetric modulated arc plans with 6 MV, 10 MV and 15 MV photon energies using single arc (SA) and dual arc (DA) were generated.

3.2. *CT simulation*

CT scan was done for all the patients on CT-simulator unit (Somatom Sensation Open, Siemens, Germany). Patients were instructed to follow a bladder protocol, in which each patient was asked to void the bladder and then drink approximately 1 l of water to fill the bladder. They were asked to wait for around 45 min before planning scan to ensure bladder filling. Fiducial markers were kept at the level of pubic symphysis. Orfit immobilizing casts were made for the patient and scans of 5 mm thickness were acquired in supine position and were