

# Dose variation due to change in planned position for patients with carcinoma of the cervix undergoing high-dose-rate brachytherapy- 2D dose analysis

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Received December 02, 2014; Revised January 13, 2015; Accepted January 15, 2015; Published Online January 30, 2015

## Original Article

### Abstract

**Purpose:** To assess the dosimetry to organs at risk (OARs) in lithotomy position with a planned time-dose pattern obtained from supine position. **Methods:** The sample consists of thirty patients with carcinoma of the uterine cervix, Stage II and III. Patients often feel discomfort in supine position (*S* position) when compared to lithotomy position (*M* position) due to relaxation of pelvic floor muscles after the insertion of applicator (tandem and ovoids) or before delivery of the treatment. Each patient was imaged with orthogonal X- ray radiographs simultaneously in two positions, i.e. *S* position and *M* position. Dwell time and dwell position pattern obtained from the optimized plan in *S* position was used to generate plan in *M* position. Following dose reference points (point A, pelvic wall points, bladder points, rectal, anorectum (AR point) and rectosigmoid (RS point) points) were identified for analysis in *S* and *M* positions. The dosimetric data for reference points generated by the Brachyvision TPS was analyzed. **Results:** Pelvic wall points registered lower doses in *M* position when compared to *S* position. Mean doses for right pelvic wall point (RPW) and left pelvic wall point (LPW) were reduced by -10.02 % and -11.5% in *M* position, respectively. International Commission on Radiation Units and Measurements (ICRU) bladder point also registered lower doses in *M* position with a mean dose of -6.8%. Rectal point showed dose reduction by mean of -6.4%. AR and RS points showed an increased dose in *M* position by a mean of 16.5% and 10%, respectively. **Conclusion:** Current dosimetry procedure serves as a model with time-dose pattern planned for *S* position, but delivered in *M* position, without dose optimization. Prioritization of comfort and position can be considered in conjunction with optimization of dose.

**Keywords:** Supine; Lithotomy; Time Dose Pattern; Bladder; Rectum

### Introduction

Carcinoma of the uterine cervix is a radiosensitive tumour. Radiotherapy is primary modality of treatment in locally advanced uterine cervix cancers. Intracavitary brachytherapy (ICBT) along with external beam radiotherapy (EBRT) are essential components of cervical cancer management. ICBT has a high therapeutic index by delivering high dose to the tumour and lower doses to adjacent organs (without increase in toxicity), resulting in increased local control and survival.<sup>1-4</sup> Radiotherapy is a multi-stage, complex procedure requires high level of accuracy at each stage to achieve maximum tumour control with minimum normal tissue complications.

High dose rate (HDR) brachytherapy is comparable to low dose rate (LDR) brachytherapy in treatment of uterine cervix cancers. The advantages of HDR over LDR brachytherapy have been extensively reviewed.<sup>5-8</sup> Since HDR brachythera-

py is fractionated, treatment planning and dose optimization is recommended for each fraction for the following reasons. First, the anatomy of the region (uterine cervix and upper vagina) changes during the course of irradiation. Second, geometry of the applicators changes as a consequence of the differences in vaginal packing and anatomical position of the patient.<sup>9-15</sup> As a result every parameter that influences the treatment should be thoroughly studied.

Cancer uterine cervix patients often feel discomfort during intracavitary brachytherapy application procedure and treatment. Discomfort can be addressed with application under short sedation in supine position (*S* position), which is the usual anatomical position for treatment delivery. This discomfort is reduced for some patients in lithotomy position (*M* position) because of the relaxation of muscles of the pelvis. Adopting lithotomy position requires repetition of the

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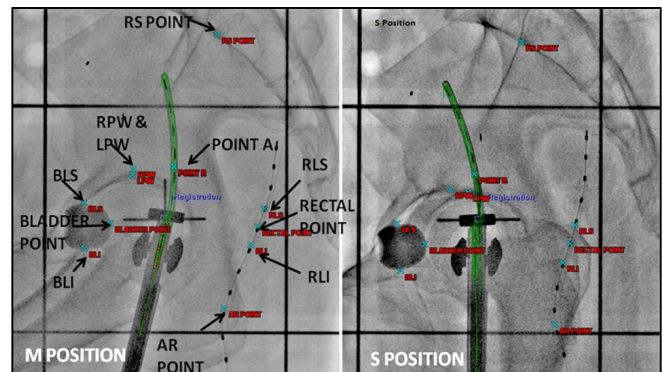
Cite this article as: Talluri AK, Yarrama AR, Ahamed S, Gudipudi DK, Sresty NVN, Alluri KR, Puriparthi L. Dose variation due to change in planned position for patients with carcinoma of the cervix undergoing high-dose-rate brachytherapy- 2D dose analysis. *Int J Cancer Ther Oncol* 2015; 3(1):030121.  
DOI: 10.14319/ijcto.0301.21

The current study serves to evaluate a case scenario using lithotomy position. An analysis of the risk involved, if any, with respect to higher doses to organs at risk (OARs) can be studied if patient comfort is prioritized. United States Nuclear Regulatory Commission (USNRC) standards document <sup>18</sup> throws light on HDR brachytherapy issues such as wrong site treated, wrong dose delivered etc. Present article adds to the current literature in analysing situations where in dosimetry is assessed with patients in M position with the time-dose pattern obtained from S position.

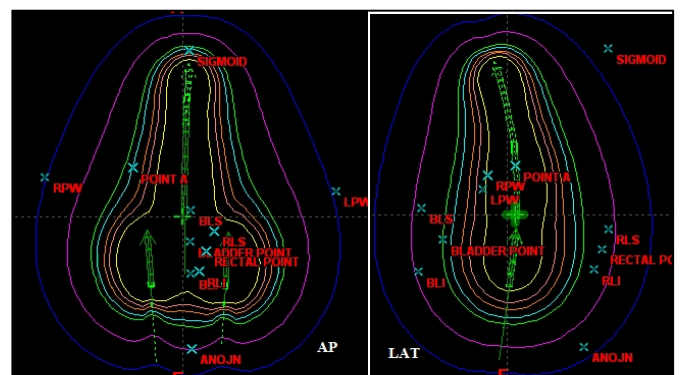
The study sample consists of thirty patients with carcinoma uterine cervix, Stage II and grade III with age ranging from 30 - 60 years. All patients were recruited with the approval of hospital ethics committee. Standard Henschke applicator set (Mick Radio-Nuclear Instruments, Inc., NY, and USA) with different tandem lengths and ovoid diameters was used depending on patients' anatomy. Tandem length varies between 4 to 6 cm and ovoids diameter ranges from 2 to 3 cm. Each patient was imaged simultaneously in two positions, i.e. S Position and M Position, on Acuity physical simulator (Varian, Palo Alto, CA, USA). Orthogonal digital X-ray images in anterior-posterior and lateral directions at gantry angles 0° and 270° respectively were obtained to confirm the adequacy of position and orientation of the applicator set. Images were transferred to the Brachyvision treatment planning system (TPS), version 7.3 (Varian Medical System, Palo Alto, CA, USA) via ARIA network (Varian, Palo Alto, CA, USA) for planning.

algorithm with a dose calculation grid size of 2 mm. Typical dose distribution is shown in the **Figure 2**.

Point A, pelvic wall reference points and bladder points are identified in accordance with International Commission on Radiation Units and Measurements (ICRU) 38 recommendations.<sup>20</sup> In addition to the ICRU bladder point, two more points were digitized at superior and inferior surface of the Foleys' bulb (**Figure 1**). A dummy marker wire is placed in the rectal tube to locate the modified rectal point. Rectal point was identified at a point anterior to the rectal marker wire in lateral view at the level of line joining the centres of right and left femoral heads in anterior-posterior view. Two additional rectal points are marked at 1 cm on either side of the modified rectal point in cranio-caudal direction. AR point was mimicked with a point located at 2 cm superior to the point on the rectal marker wire at the inferior level of pelvic girdle. RS point was identified at the anterior surface of S1-S2 junction in lateral view and at the same level on the midline in anterior-posterior view.



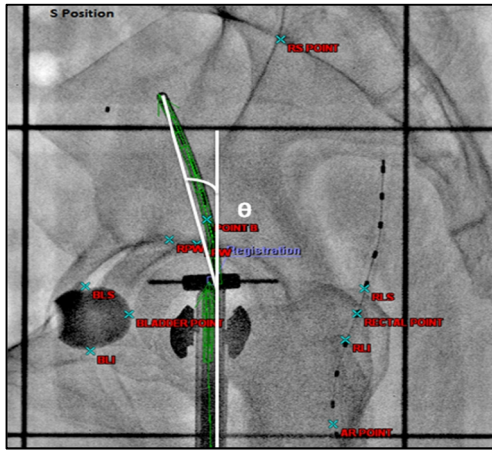
**FIG. 1:** Lateral X- ray radiographs in  $M$  and  $S$  positions.



**FIG. 2:** Typical Isodose distribution.

Pitch of the tandem applicator is obtained by measuring the angle between the line passing from the tip of the tandem through centre of the flange and a line parallel to the length of the template field of size 10 cm × 10 cm used to scale the radiograph, along the patient, on the lateral radiograph (**Figure 3**). The difference of the measured angles, ( $\theta_1 - \theta_2$ ), in S ( $\theta_1$ ) and M ( $\theta_2$ ) positions gives an estimate of the pitch due to

change in anatomical position (**Figure 3**). Data normality was assessed using the Klomogorov-Smirnov test and statistical analysis was performed using the software SAS version 9.4 (SAS Institute., Inc., Cary, NC). *P*-values were calculated with Student's paired *t* test.



**FIG.3:** Pitch of the applicator with respect to external template field.

## Results

The dosimetric data of dose reference points generated by the Brachyvision TPS was analyzed. The relative variation of doses in two anatomical positions is expressed as ratio of dose difference between *M* and *S* positions to dose in *S* position. A positive value indicates higher dose in *M* position and a negative value indicates a lower dose. Out of 30 patients, 23 patients received 7 Gy, 3 patients received 6.5 Gy, and 4 patients received 6 Gy, per fraction. Point A exhibited a little dose difference in two positions with a range from -6.9% to 5.4% and a mean of 0.3%.

**TABLE 1:** The mean dose differences between TPS values in *M* and *S* positions as percentage of values obtained with patient in *S* position.

Point/ OAR	Mean dose difference	<i>p</i> value
RPW	-10.02	<0.001
LPW	-11.5	<0.001
Bladder point	-6.8	<0.001
Rectal point	-6.4	0.007
AR point	16.5	<0.001
RS point	10.0	<0.001

Pelvic wall points registered lower doses in *M* position when compared to *S* position. For the right pelvic wall point (RPW), the mean dose was -10.02% with a range from 7.7% to -28.2%. For the left pelvic wall point (LPW), the mean dose was -11.5% with a range from 5.2% to -29.7%. ICRU bladder point also registered lower doses in *M* position with a range from 5.2% to -29.7% with a mean dose of -6.8%. Rectal point showed reduction in dose by mean of -6.4% with a range from -26.9% to 15.1%. Anorectal junction point and Rectosigmoid point showed an increased dose in *M* position by a mean of 16.5% with a range from -2.58% to 34.1%

and with a mean of 10% with a range from -19.4% to 32.5%, respectively.

## Discussions

The main aim of the study was to assess the change in dosimetry due to change in patients' anatomical position. In the present study, 60 plans on thirty patients with two plans per patient in *S* and *M* positions were created and analyzed. Different treatment positions are evaluated in both external beam therapy<sup>21-23</sup> and brachytherapy<sup>24-27</sup> for treatment of various sites. In case of brachytherapy there are studies on the use of template based standard plans versus individualized plans and pre-prepared treatment plans for curved structures such as esophagus.<sup>28</sup> There are few studies which evaluated variability of position of ring and tandem applicators<sup>29-30</sup> in ICBT in cancer cervix patients. Vaginal cuff irradiation is well studied with change in applicator angle<sup>32</sup> and patients position.<sup>33</sup> This study is one of the very few studies done till date to evaluate dosimetric variations in different anatomical positions in cervical cancer patients when treated with tandem and ovoid applicator.

To characterize the applicator orientation changes additional dose reference points are added for rectum and bladder points and analyzed. Analysis of posterior reference points shows increase of dose in craniocaudal direction from RS point till inferior rectal point (RLI) (**Figure 4**). RS and AR points receive lower doses compared to rectal points as they are located at the extreme ends of the source arrangement. From **Figure 4** it can be inferred that the dose to posterior points follows a similar trend for both positions. However, higher doses are observed for rectal points in *S* position and RS and AR points in *M* position. Among the anterior reference points, bladder superior point (BLS) shows a decrease in dose in *S* position and bladder inferior point (BLI) dose is higher in *M* position. Rearrangement in applicator-anatomy was observed from *S* position to *M* position, as same dwell time pattern is adopted for both positions. It was observed that in *M* position posterior points registered relatively flatter values as compare to *S* position. **Figure 5** shows the mean dose variations of anterior reference points. Dose decreased to BLS point by a mean of -9.8% and an increase in dose to BLI point by 2.9% was observed in *M* position. Tandem rotation towards posterior structures in *M* position was observed with tip of the tandem drifting away from BLS point resulting in higher dose to BLS point. The mean difference in rotations was 10° between two positions and consequently the mean dose to RS and AR points were increased in *M* position. Previous studies measured translational shifts only in anterior-posterior direction<sup>26</sup> or in other applicator geometry such as ring and tandem for one anatomical position i.e., supine only.<sup>30-31</sup> Rotational shift associated with change in applicator angle was reported by Hoskins *et al.*<sup>32</sup> and is about 20°. The higher degree of rotation reported in their study may be due to single line source used for vaginal cuff

brachytherapy. This is not the case with tandem and ovoid pair applicators used for cancer of cervix and the rotation reported in this case is not comparable to that for vault brachytherapy.

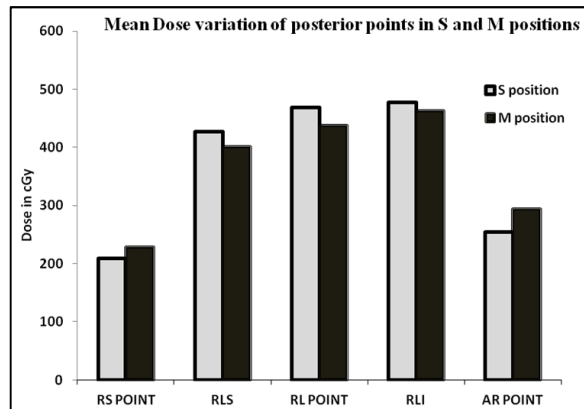


FIG. 4: Mean dose variation of posterior points in *S* and *M* positions.

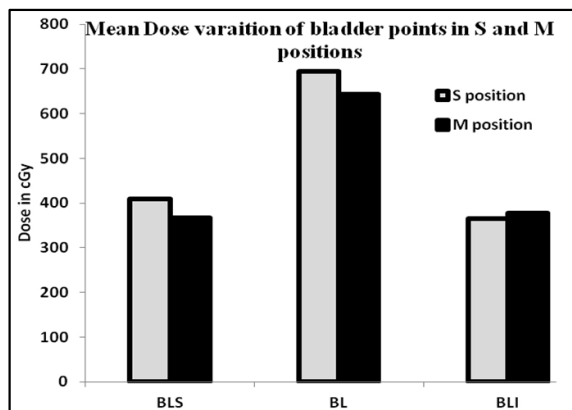


FIG. 5: Mean dose variation for bladder points in *S* and *M* positions.

The consequences of transposing dwell pattern to *M* position are summarized. Dose to RS and AR points maximized in most of the cases. Both these points recorded a maximum of 30%. Pelvic wall points, on the contrary, recorded a minimum, close to 30%. Similarly, reduction in dose to BLS point was compromised with a higher dose to BLI point. However, the mean dose to the bladder and rectum points was on the lower side which is a favourable result.

## Conclusion

This study presents a case scenario, evaluating lithotomy position for dosimetry of various OARs. We conclude that reduction in dose to bladder and rectum is compromised with elevated doses to rectosigmoid and anorectal points. The current dosimetry procedure serves as a future model and can be correlated with a patient treated with time-dose pattern planned for *S* position, but delivered in *M* position, without dose optimization. Prioritization of comfort and position can be taken seriously but in conjunction with op-

timization of dose. Further studies in this respect with 3D planning are needed to add to the literature.

## Conflict of interest

The authors declare that they have no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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