

# Image Guided Brachytherapy in Cervix Cancer

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## ABSTRACT

Brachytherapy has a long history in the treatment of cancer. However, the treatment planning technique for brachytherapy has lagged somewhat behind the corresponding developments for external beam therapy as far as the imaging technique is concerned. Currently, the orthogonal-film-based treatment planning is performed at most institutions even though the CT-based planning is available. The aim of this study is to evaluate the CT-based vs. the orthogonal-film-based treatment planning in cervix cancer. The doses to point A, point B, rectum and bladder points according to ICRU 38 were calculated for the two methods above. In addition, the volumetric studies such as 3D dose computation and DVH were obtained for the CT-based planning. For the bulky tumor, the isodose lines of point A prescription were not fairly covered for the CTV. The CT-based dose planning can overestimate the maximum dose delivered to bladder and rectum by 30%. The CT-based planning has several advantages over the orthogonal-film-based such as 3D dose display, DVH, and more accurate target delineation. It is suggested that the prescription point in cervix cancer be revised especially for the bulky tumor.

**Keywords:** Brachytherapy, ICRU 38, rectum, bladder, DVH

## 1. INTRODUCTION

It has been more than 100 years since the placement of radioactive sources in or near tissue for the treatment of cancer. However, the treatment planning technique for brachytherapy has lagged somewhat behind the corresponding developments for external beam therapy as far as the use of imaging technique is concerned. Currently, the orthogonal-film-based treatment planning is performed at most institutions even though the CT-based planning is available. The orthogonal-film-based technique provide the position of the applicator relative to bony structures; this allows the calculations of doses at fixed points (point A and B) related to the applicator, to bony structures, and to reference points for the organs at risk such as bladder and rectum. The CT-based technique provides the volumetric study, which allows to evaluate dose distributions in different volumes, such as the gross tumor volume (GTV), clinical target volume (CTV), and organs at risk. In this study, the comparison of the orthogonal-film-based and the CT-based treatment planning was performed for point A, point B, rectum and bladder points according to ICRU 38 in a feasibility study involving 10 patients.

## 2. MATERIALS AND METHODS

External beam therapy (15MV) with a linear accelerator was given at a dose of 40 and 1.8 Gy per daily fraction applying the four-field box technique. High Dose Rate (HDR) brachytherapy with Iridium-192 was performed in six fractions at a dose of 4 Gy to point A per fraction. For CT scan the modified Fletcher-Williamson applicator set was used with different lengths of intrauterine tubes instead of CT-MR applicator by Nucletron because of certain limitations. Also, the 2 cm diameter of plastic ovoid cap was used for all patients. This applicator set was used for the orthogonal-film-based technique in order to make these two techniques geometrically identical. A series of CT images obtained with the applicator in place was taken for the delineation of CTV, bladder and rectum. For the orthogonal-film-based treatment the orthogonal radiographs were taken with a reconstruction box by Nucletron. A great care should be taken for obtaining the images in order to keep the geometry same in the two treatment techniques. The two treatment planning methods were done with the PLATO system (BPS v13.7, BPS v14.2, Eval v2.9). Point A, B and in the ICRU rectum and bladder points were marked and calculated for the two plans, respectively. Prescribed dose at point A was defined relative to the applicator: 2 cm up and 2 cm lateral from the cervical os on the intrauterine tube. For the CT-based plan the 3-D visualization of target volumes and organs at risk was obtained. The 3-D visualization of pelvis is shown in Fig. 1. In order to compare the two plans above, CTV based plan was also performed. In addition, the dose-volume histogram (DVH) for CTV, bladder and rectum was computed in detailed comparison.



Fig. 1. The three dimensional display of pelvis

### 3. RESULTS

The calculated average volume of the CTV for 10 patients was  $12.9 \pm 5.9 \text{ cm}^3$ . The calculated mean volumes of the bladder and the rectum were  $124.4 \pm 40.4 \text{ cm}^3$  and  $58.0 \pm 29.2 \text{ cm}^3$ , respectively. In the orthogonal-film-based technique, the target volume of 100% isodose lines covered was  $130.3 \pm 16.6 \text{ cm}^3$ . However, the target volume of 100% isodose lines covered was  $72.0 \pm 21.4 \text{ cm}^3$  in CT-based technique. An example of isodose distribution for CT image is shown in Fig. 2.

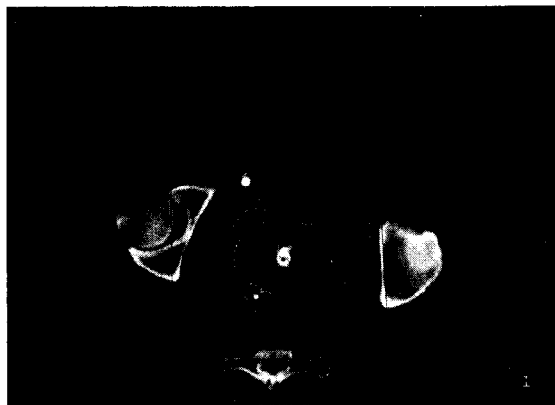


Fig. 2. Isodose distribution on CT image

According to the ICRU 38 recommendation, the bladder doses for the orthogonal-film and the CT-based techniques were  $92.9 \pm 21.9\%$  and  $67.3 \pm 23.5\%$  relative to point A dose, respectively. In addition, the rectum doses for the orthogonal-film and the CT-based techniques were  $88.1 \pm 19.8\%$  and  $77.3 \pm 17.7\%$  relative to point A dose, respectively. The maximum doses for the bladder and the rectum in the orthogonal-film-based technique were  $139.7 \pm 56.2\%$  and  $106.8 \pm 45.2\%$ , respectively. However, the maximum doses for the bladder and the rectum in the CT-based technique were  $107.3 \pm 53.2\%$  and  $90.3 \pm 33.2\%$ , respectively. The DVH for CTV, bladder and rectum was obtained and compared for all patients studied. Based on the ICRU 38 recommendation, the volumes of the rectums receiving over 80 % of target volume doses for the orthogonal-film and the CT- based techniques were  $2.51 \pm 2.96\%$  and  $1.13 \pm 3.40\%$ , respectively. By the same token, the volumes of the bladders receiving over 80 % of target volume doses for the orthogonal-film and the CT- based techniques were  $10.0 \pm 6.7\%$  and  $2.8 \pm 10.2\%$ , respectively. An example of the DVH for the CT-based technique is shown in Fig. 3.

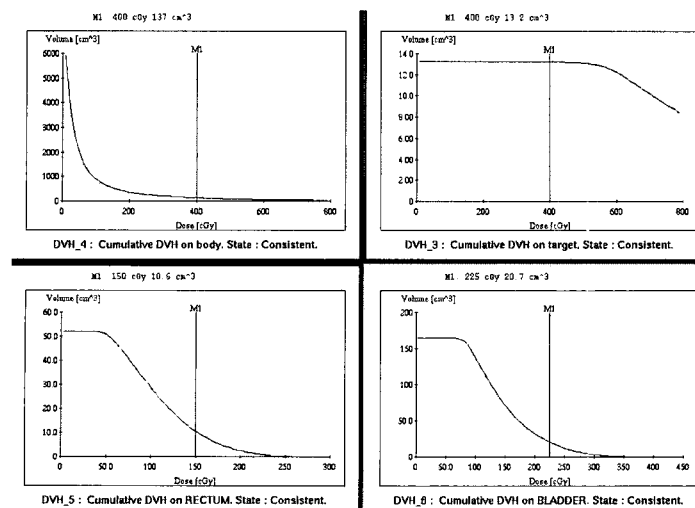


Fig. 3. DVH for target and organs at risk

#### 4. DISCUSSION

In most clinical settings the treatment planning for intracavitary brachytherapy of gynecological malignancies rely on orthogonal two-dimensional radiographs to identify the coordinates of radioactive sources in the patient frame of reference. With these two radiographs, the calculation of the isodose distribution is based on the visualization of the applicator relative to the bony structure. In fact, this technique does not imply the evaluation as to what extent the treated volume encompasses the CTV. However, the CT-based technique provides the delineation in each slice of the CTV and organs at risk. From this information, it makes the three-dimensional dose planning and the volumetric study possible (DVH). The target volumes of 100% isodose lines covered for the orthogonal-film-based technique and the CT-based technique were  $130.3 \pm 16.6 \text{ cm}^3$  and  $72.0 \pm 21.4 \text{ cm}^3$ , respectively. This means that the unnecessarily volume is irradiated for the orthogonal-film-based technique. By comparing the bladder and the rectum doses for the two plans according to the ICRU 38, this shows that the CT-based technique is superior than the orthogonal-film based technique by more than 20%. The maximum dose differences for the bladder and the rectum for the two plans were 32.4 % and 16.5 %, respectively. For the DVH comparison, the normal tissue in the CT-based technique was less irradiated.

#### 5. CONCLUSION

In this study, the comparison of the CT-based technique over the orthogonal-film based technique was examined. A three-dimensional treatment planning seems to be advantageous compared to the orthogonal-film based technique. It is possible that the CT-based technique can reduce the unnecessarily doses to the normal tissue with better visualization. It is suggested that the prescription point in cervix cancer be revised especially for the bulky tumor.

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