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Three-dimensional treatment planning for vaginal cuff brachytherapy: Dosimetric effects on organs at risk according to patients position

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ABSTRACT

PURPOSE: Aim of this study was to evaluate dose distribution within organs at risk (OARs) and planning target volume (PTV) based on three-dimensional treatment planning according to two different setup positions in endometrial carcinoma patients submitted to postoperative brachy-radiotherapy on vaginal vault.

METHODS AND MATERIALS: Patients with endometrial cancer necessitating of adjuvant brachytherapy on vaginal vault were enrolled. Pelvic computed tomography studies were prospectively obtained in two different setup positions: extend legs (A position) and gynecological (B position). Contoured OARs were bladder, rectum, and small bowel. The PTV was identified as applicator's surface with an isotropic 5-mm margin expansion. Radiation dose delivered in 1 cc (D_{1cc}) and 2 cc (D_{2cc}) of OAR were calculated.

RESULTS: Coverage of PTV and values of D_{1cc} and D_{2cc} obtained for bladder and small bowel were similar in the two positions. For rectum, both D_{1cc} and D_{2cc} had statistically significant lower values in A with respect to B position.

CONCLUSIONS: Both in A and B positions, radiation doses delivered do not exceed the dose constraints. However, A setup seems to significantly reduce doses to rectum while obtaining the same PTV coverage. The findings from our study provide evidence supporting the use of A position setup for delivering vaginal vault brachytherapy.

Keywords: Brachytherapy; Set up position; 3D planning

Introduction

Brachytherapy enables to deliver a localized radiation dose to the vaginal vault and upper vagina after hysterectomy. It is generally employed as postoperative treatment after hysterectomy for endometrial carcinoma patients in pathologic Stage I–III tumors. It may be used alone, in patients with Stage I–II and low-grade histology, or in combination with external beam treatment in patients with more advanced disease (1, 2). In treating vaginal vault, the treatment is complicated by the proximity to normal tissues such as the anterior rectal wall, the bladder base, and the small bowel (3). High-dose-rate afterloading for gynecological brachytherapy has been shown to offer significant advantages with respect to both medium- and low-dose-rate insertions owing to more accurate applicators' fixation for the short treatment period. In particular, there is lesser discomfort of vaginal packing and applicators during bed immobilization and displacement of the applicators (4). Crucial to this concept is the position of normal anatomic structures around the applicator (5), and it is demonstrated that the applicator's angle could be influenced by the patient's position (6). There are no specific recommendations on this issue; in

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fact, some centers prefer that the patient had lithotomy set up position, other prefer extended legs set up position (7–9).

For this reason, we have prospectively evaluated organ at risk (OAR) dose distribution and planning target volume (PTV) coverage, using three-dimensional (3D) treatment planning, according to two different set up positions, extended legs (A position) and gynecological (B position), in endometrial carcinoma patients submitted to adjuvant brachy-radiotherapy on vaginal vault.

Patients and methods

Endometrial cancer patients previously submitted to radical hysterectomy with or without pelvic lymphadenectomy were enrolled. Written informed consent was obtained from all patients before inclusion in the study. Two different set up supine positions were planned: (*1*) extended legs (A position) and (*2*) lithotomy (B position). After insertion of vaginal applicator, no effort was made to correct the natural insertion angle. Patients were catheterized, and bladder was filled with a fixed volume of 50 mL physiologic saline solution. For 3D planning, all patients underwent two consecutive pelvic computed tomography (CT) study with an indwelling catheter in place both in A and B positions, respectively. The CT scan was performed with 1.5-mm slice thickness to improve the image resolution for digitizing the source positions. All CT slices were transferred to the 3D treatment planning system OncentraBrachy (Nucletron, an Elekta company, Elekta AB, Stockholm, Sweden); based on the GEC-ESTRO recommendations (10), 3D contouring of OARs (bladder, rectum, and small bowel) was performed. PTV was identified as applicator's surface with an isotropic 5-mm margin expansion (Figs. 1a and 1b). For each plan, dose-volume histograms of OARs and PTV were calculated. For OARs, the volume dose was defined by use of two different criteria, the dose value of radiation dose delivered in 1 cc (D_{1cc}), and 2 cc (D_{2cc}) of OAR.

Questionnaire

The subjects were asked to answer to a questionnaire consisting of three boxes placed vertically, with the following items: no difference; better extended leg position; and better lithotomy position.

Statistical methods

Data normality was assessed using the Kolmogorov–Smirnov test. All radiotherapy data sets were found to be normally distributed. Results are presented as mean (standard deviation). Paired *t* tests were used to assess overall differences in groups across the two positions of interest. Pearson correlation coefficient was used for analyses of the relationships between dose distributions within OARs in the two positions. Two-sided tests were used and a *p*-value <0.05 was considered significant. All statistical analyses were performed using the software package SAS 9.2 (SAS Institute, Inc., Cary, NC).

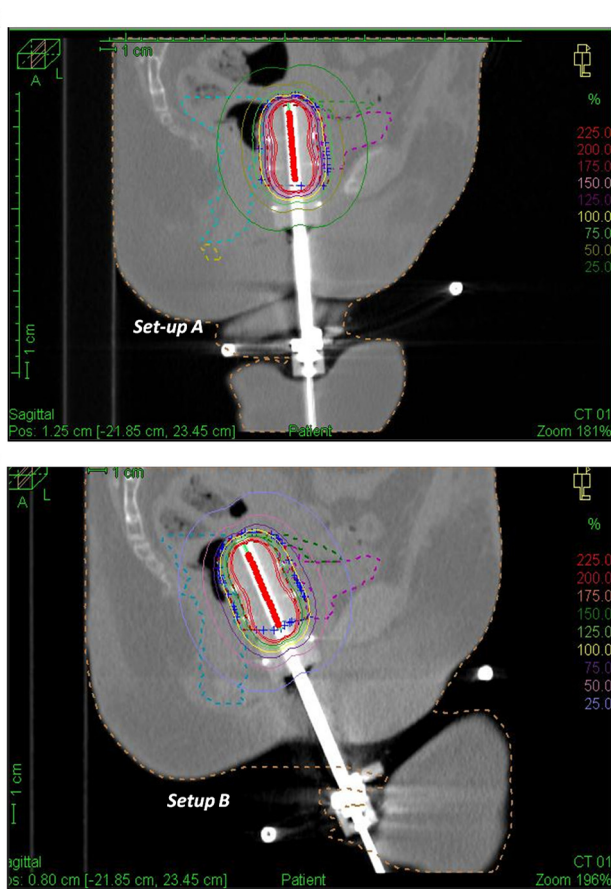

Fig. 1. A sagittal view of the three-dimensional planning in both set up position: (a) extended legs and (b) lithotomy.

Results

Twelve consecutive patients were enrolled. During 4 months, 24 pelvic CT scans were performed, 12 in A position and 12 in B position. The cylinder diameter ranged from 2.0 to 3.5 cm. For each patient, the external contours were delineated on each axial CT slice in the contouring workspace of the OncentraBrachy treatment planning by use of sagittal and coronal views for assistance. To ensure consistency of structures between the scan set, contours for each patient were closely compared and verified on corresponding CT slices. The angle of applicator in the two positions was not measured. Source positions inside the applicator were digitized and dwell times were optimized to generate the desired PTV prescription (the upper 4 cm of the vagina). The analysis of results shows, for single 5 Gy fraction, similar coverage of PTV both in A position (minimum 94.81%–maximum 99.98%) and B position (minimum 94.90%–maximum 100%). The average D_{1cc} and D_{2cc} values obtained for the rectum were 4.69 and