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Multichannel vaginal cylinder brachytherapy—Impact of tumor thickness and location on dose to organs at risk

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ABSTRACT

PURPOSE: Multichannel vaginal cylinder brachytherapy (MCVCB) has the potential to sculpt dose distribution, although this is typically reserved for lesions <5-mm thick. The aim of this study was to investigate the dosimetric consequences of treating lesions with MCVCB of varying locations, ≥5 mm in thickness.

METHODS AND MATERIALS: Patients previously treated with MCVCB were randomly selected to each fill one of six categories based on location (lateral, anterior, or vaginal cuff and/or apex) and size of cylinder (2.5 or 3.0 cm). Based on magnetic resonance image, each patient's target lesion was extended circumferentially into theoretical high-risk clinical target volumes measuring 5, 7, and 10 mm in thickness. Image-based brachytherapy treatment plans for each of the six patients' three target volumes were generated. Total 2 Gy per fraction equivalent dosages (EQD2) were calculated using an external beam radiation therapy dose of 45 Gy in 25 fractions in conjunction with a high-dose-rate brachytherapy dose of 25 Gy in five fractions.

RESULTS: Maximum EQD2 vaginal surface doses in gray for 5-, 7-, and 10-mm targets were as follows (location-cylinder size): lateral-3.0 cm: 122/153/210, lateral-2.5 cm: 145/195/301, anterior-3.0 cm: 115/135/197, anterior-2.5 cm: 132/173/283, apex-3.0 cm: 173/241/367, and apex-2.5 cm: 349/461/706. Total rectal EQD2 $D_{2\ cc}$ ranged from 53.9 to 67.2 Gy. Total bladder EQD2 $D_{2\ cc}$ ranged from 51.5 to 71.2 Gy.

CONCLUSIONS: The vaginal surface dose seems to be the dose-limiting structure for anterior, lateral, and apical vaginal lesions. Caution should be taken when treating lesions >5 mm in depth, with particular attention to vaginal surface dose, especially for apical lesions and with smaller cylinders. In such cases, interstitial brachytherapy should be given strong consideration.

Keywords: Multichannel vaginal cylinder; Brachytherapy; Vaginal toxicity; Tumor size; Vaginal cancer; Dosimetry

Introduction

Radiotherapy, in particular brachytherapy, plays an integral role in the treatment of both primary vaginal cancers and for recurrent tumors located in the vagina (1−6). The overall radiation regimen for these patients typically consists of brachytherapy in combination with external beam radiation therapy (EBRT), although in some cases treatment is with brachytherapy alone or EBRT alone (7−9). Despite recent trends of decreasing utilization of brachytherapy boost, no other modality can provide as conformal a boost dose as brachytherapy (10). Numerous brachytherapy techniques have been used in treating vaginal tumors including single-channel vaginal cylinder brachytherapy (SCVCB), multichannel vaginal cylinder brachytherapy (MCVCB), interstitial brachytherapy, and hybrid cylinder plus needles applicators. The choice of which technique to use for any given patient is a multifactorial decision based on tumor location, thickness, and extent of residual disease after EBRT.

The use of SCVCB to treat the superficial vaginal mucosa in the adjuvant setting of endometrial cancer effectively decreases the risk of local recurrence and is well tolerated, making the extension of its use to the setting of superficial recurrent or primary cancer both natural and desirable (11,

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12). However, due to the relative lack of ability to control the shape and spread out of dose with SCVCB, its utilization has traditionally been limited to residual tumors ≤5 mm in thickness and limited to the proximal part of the vagina. American Brachytherapy Society (ABS) guidelines suggest interstitial brachytherapy as the preferred modality for lesion >5 mm in thickness (12, 13). The increased dose conformality associated with interstitial brachytherapy comes at a cost. Compared with interstitial brachytherapy, cylinder-based brachytherapy is associated with less procedural morbidity as it does not involve violation of tissue planes and does not typically require anesthesia, prolonged immobilization, or hospitalization.

More recently, brachytherapy techniques such as MCVCB and hybrid cylinder−interstitial applicators have been developed to attempt to bridge the gap between the tolerability of cylinder-based brachytherapy and the dosimetric advantages of interstitial brachytherapy. The advantages of MCVCB over SCVCB, in particular greater coverage of the target with decreased dose to organs at risk (OAR), have been described both by our group and others (14−16). We have recently published our experience with 41 patients treated with image-based high-dose-rate (HDR) MCVCB, showing excellent local control and low toxicities (17).

Multiple factors influence which brachytherapy technique to use for any given patient with the two dominant factors being tumor location and size. In the era of three-dimensional conformal brachytherapy, dosages to OAR play an increasingly important role in patient selection. However, until the applicator is placed and three-dimensional imaging is performed, it is difficult to accurately estimate the doses to OAR in advance. Thus, questions remain as to which exact patients may be eligible for treatment with MCVCB vs. interstitial brachytherapy. Although the effects of prescription depth and cylinder size have been described for SCVCB (18), there is a paucity of data on the effect of tumor depth and location on the dose to OAR in the setting of MCVCB. In this study, we aimed to analyze the effect of tumor size and location on the doses to nearby OAR to help define which patients are appropriate candidates for MCVCB and offer guidance on patient selection.

Methods and materials

In this institutional review board−approved study, we retrospectively identified patients with recurrent or primary vaginal carcinoma who had residual disease ≤5 mm in thickness after EBRT and were then treated with MCVCB. Six patients were randomly selected to each fill one of six categories based on the diameter cylinder used (2.5 or 3.0 cm) and tumor location (anterior Fig. 1, lateral Fig. 2, or apical Fig. 3). Because of the proximity of the rectum, patients with posterior lesions were not evaluated as patients with tumors ≥5 mm located posteriorly would have unacceptably high rectal doses given that the rectovaginal septum is typically <5-mm thick and the tolerance of the rectum is less than the prescription dose.

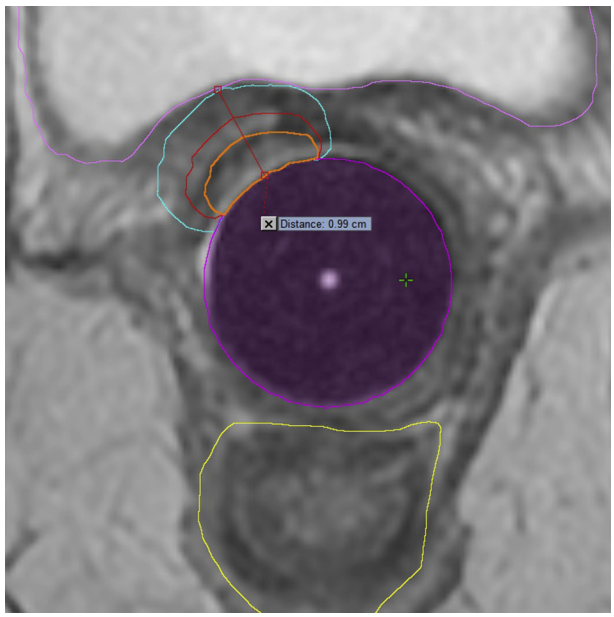

Fig. 1. Anterior 5-, 7-, and 10-mm deep lesions in axial view.

Each patient's lesion and nearby OAR were contoured three-dimensionally in accordance with published guidelines (19, 20). Nearby OAR included the rectum, bladder, and vaginal mucosa. The vaginal wall was contoured three-dimensionally based on the magnetic resonance image MRI; Fig. 4. Contours for the six patients' target lesion

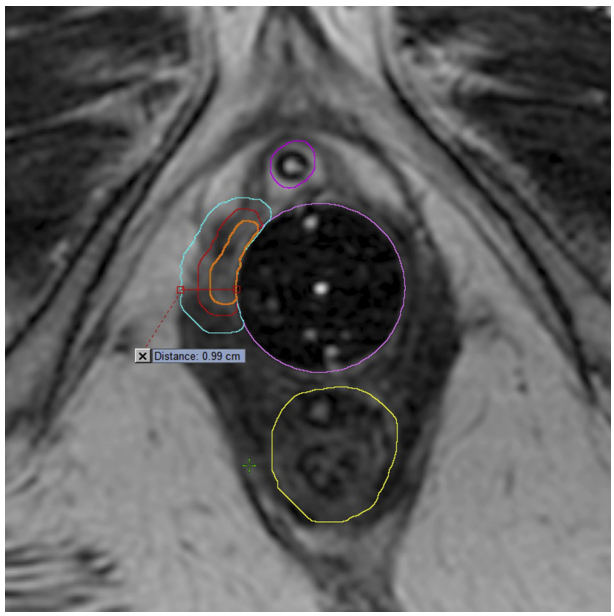

Fig. 2. Lateral 5-, 7-, and 10-mm deep lesions in axial view.