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Dosimetric advantages of using multichannel balloons compared to single-channel cylinders for high-dose-rate vaginal cuff brachytherapy

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ABSTRACT

PURPOSE: To evaluate the dosimetric advantages of using multichannel balloons (MCBs) vs. single-channel cylinders (SCCs) for high-dose-rate vaginal cuff brachytherapy.

METHODS AND MATERIALS: A total of 91 consecutive high-dose-rate vaginal cuff brachytherapy including 45 MCB and 46 SCC treatments were reviewed. The clinical target volume (CTV) was defined as a 0.5-cm uniform expansion of the applicator surface from vaginal apex for 3 cm. For dosimetric comparison, we normalized prescription dose per fraction to 700 cGy and optimized each plan to cover at least 90% of CTV. CTV-1 cm, the true vaginal cuff volume, was defined as proximal 1 cm of CTV from vaginal apex. Four quality indices including conformity index (CI), dose homogeneity index, dose nonuniformity index, and overdose index were compared.

RESULTS: The CTV and CTV-1 cm were significantly larger for MCB cases compared to SCC cases. Evaluating CTV coverage, the mean dose homogeneity index and dose nonuniformity index were superior for MCB than SCC. No differences were noted regarding CI and overdose index between MCB and SCC cases. However, focusing on CTV-1 cm, the difference of CI became significant in favor of MCB cases. In addition, the mean point dose at 0.5-cm depth from the apex was significantly lower in SCC cases compared to cases by MCB treatment, indicating inadequate vaginal apex coverage by SCC treatment.

CONCLUSIONS: Compared to SCC, MCB treats a larger volume and offers a more conformal and homogeneous target coverage. In addition, a lower dose at the vaginal apex due to SCCs source anisotropy can be minimized.

Keywords: Endometrial carcinoma; Vaginal cuff brachytherapy; Multichannel balloon

Introduction

Postoperative vaginal cuff brachytherapy (VBT) alone or in combination with external beam radiotherapy (EBRT) has become an integral component in the management of gynecologic cancers. Cancers of uterine corpus and cervix represent the most common and the third most common gynecologic malignancies in the United States. In 2015, it was estimated that there were 54,870 and 12,900 new diagnoses and 10,170 and 4,100 deaths, respectively (1). The standard of care for nonmetastatic endometrial cancer and early-staged cervical cancer is radical surgery. Postoperatively, radiotherapy and/or chemotherapy are added based on individual risk features to reduce risks of recurrence and achieve a better prognosis. With the publication of PORTEC-2 trial, VBT alone is considered a reasonable treatment for patients with Stage I endometrial cancer of high-intermediate risk (2). For patients with Stage II or III endometrial cancer, pelvic EBRT plus VBT oftentimes is recommended. Although there is no general agreement on the routine usage of VBT following hysterectomy for cervical cancer, EBRT plus VBT should be considered in patients with a high risk of vaginal or pelvic recurrence, such as less than radical surgery, close or positive margin at the vaginal vault, deep stromal invasion, extensive lymphovascular invasion, or positive lymph nodes (3).

VBT often involves the insertion of a rigid single-channel cylinder (SCC) into the vagina for treatment. To

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make sure that the SCC is in direct contact with the mucosa of the vaginal apex for an effective treatment, it is recommended to use the largest diameter SCC that fits in the vagina, which obviously could cause significant discomfort and, sometimes, vaginal cuff dehiscence (4). Although the shape of the postoperative vagina is cylindrical, the vaginal cuff, which is the target of treatment, could have a somewhat ''dog-ear'' configuration and therefore treatment delivered by using an SCC might be inadequate (5). In addition, because the dose distribution with the SCC is uniform around the applicator, the dose to rectum and bladder cannot be reduced without decreasing the prescription dose to the target volume. The Capri applicator (Varian Medical Systems, Inc., Palo Alto, CA) is a multichannel balloon (MCB) applicator designed for intravaginal brachytherapy (6). It has 13 channels to allow for greater dose flexibility, and the soft silicone exterior can be inflated to conform to the shape of the vaginal canal for a more effective treatment.

At City of Hope Medical Center, we adopted the MCB Capri applicator for intravaginal brachytherapy since June 2014. Hypothesizing MCB would provide more conformal and homogeneous target coverage, the purpose of this study is to evaluate the dosimetric advantages of using MCB compared to SCC for high-dose-rate (HDR) VBT.

Methods and materials

This retrospective study consisted of 58 consecutive patients with 41 endometrial cancer and 17 cervical cancer referred to the Department of Radiation Oncology, City of Hope Medical Center for HDR VBT. The study was approved by the Institutional Review Board at City of Hope Medical Center. The patients were treated between January 2011 and September 2015. All the patients with either endometrial or cervical cancers who received adjuvant VBT alone or a combination of EBRT and VBT after surgery were included in the study. Before treatment, each patient had a pelvic examination and the vaginal vault size was determined. For cases before June 2014, we used SCC (CT and MR compatible vaginal cylinder, GM11004140; Varian Medical Systems, Inc., Palo Alto, CA) with variable sizes for VBT. The largest diameter SCC that could fit comfortably was advanced to be in direct contact with the vaginal apex mucosa and the SCC was then secured in place for treatment. After, June 2014, an MCB, the Capri applicator, was used for treatment (Fig. 1). The deflated MCB was inserted up to the vaginal apex and inflated with air to adapt to the patient's vaginal anatomy. The inflation stopped when the patient felt and expressed pressure discomfort and the MCB was secured in place for treatment. All patients underwent pelvic CT simulation with 2.5-mm slice thickness to confirm the position of the applicators before each treatment fraction. The studies were then transferred to Varian Eclipse Treatment Planning System, V11.0 (Varian Medical Systems, Palo Alto, CA) for brachytherapy treatment planning. The dose was prescribed to a depth of 0.5 cm to cover proximal 3−5 cm of the vagina. The prescriptions were 700 cGy per fraction for a total of three fractions for brachytherapy alone or 400 cGy per fraction for three fractions if it was combined with EBRT. Because there is no benefit of

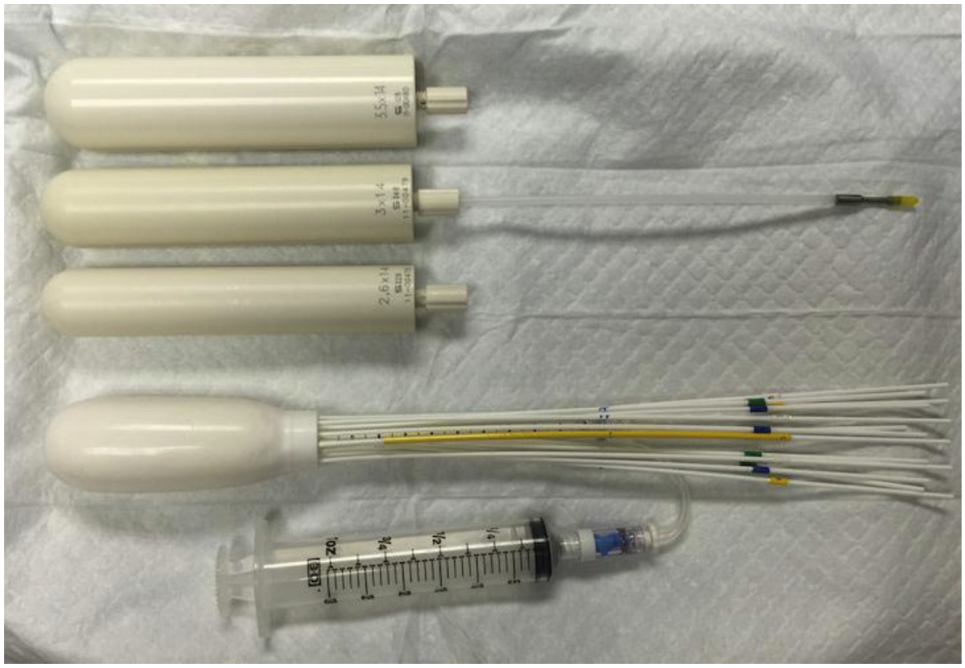

Fig. 1. Single-channel cylinder with different sizes at the top and multichannel balloon at the bottom.