EXCERPT

High-dose intracavitary brachytherapy treatment planning using multichannel vaginal cylinders, CT simulation and the [DEVICE NAME] system

Abstract

Interstitial and intracavitary brachytherapy (BT) is an important treatment modality for many gynecologic cancers. Using three-dimensional imaging with computed tomography (CT) and magnetic resonance imaging (MRI) during BT planning enables clinicians to better define the clinical target volume definition, focus radiation treatment on malignant tissue, and reduce dose to organs at risk. The use of multichannel vaginal cylinders further refines dose control by specifying source dwell positions and optimizing dwell time sequence for individual patients. We report four cases of vaginal cancer for which high-dose intracavitary BT treatment planning was performed using CT simulation and multichannel vaginal cylinders on the [DEVICE NAME] treatment planning system. For each case, we calculated the dose coverage to the clinical tumor volume and to the bladder and rectum (D2cc and D1cc). We then compared these values with those obtained from hypothetical treatment planning with single-channel vaginal cylinders normalized to a depth of 0.5 cm and to the edge of the clinical target volume. Treatment planning with multichannel vaginal cylinders on the [DEVICE NAME] system better spared bladder and rectal tissue while optimizing dose coverage to target volume. These findings illustrate the advantages of this modality for planning intracavitary BT for certain vaginal cancers.

Introduction

Gynecologic cancers comprise an estimated 5.1 million new cancer cases and 2.9 million cancer fatalities worldwide every year (Sankaranarayanan 2006, Ferlay 2002). Cervical and ovarian cancers are the most common and deadly gynecologic cancers, accounting for an estimated 697,000 new cases and 398,000 deaths annually (Sankaranarayanan 2006, Ferlay 2002). Furthermore, choriocarcinomas and cancers of the vulva, vagina, and uterine body are associated with tens of thousands of additional fatalities every year.

Interstitial and intracavitary brachytherapy (BT) are important tools for treating gynecologic cancers (De Ieso 2012, Potter 2011). For earlier stage endometrial cancers, adjuvant high-dose-rate BT is preferred over external beam radiotherapy (EBRT) (Solhjem 2005). Results from the PORTEC-2 study highlight the role of BT in preventing local tumor recurrence, minimizing adverse effects from radiation, and improving quality of life for patients with gynecologic cancers (Gaztañaga 2012, Nout 2012, Nout 2010, Nout 2009).

The use of CT simulation enables clinicians to determine the dose to organs at risk during multi-fraction high-dose rate vaginal cylinder BT (Tanderup 2004, Holloway 2011). Multichannel vaginal cylinders offer superior dosimetry and dose control compared with single-channel designs, permitting more flexibility and higher dosing of the target while

decreasing doses to surrounding rectal and bladder tissue (Demanes 1999, Tanderup 2004, Park 2012). Particularly when combined with three-dimensional imaging, multichannel vaginal cylinders enable clinicians to set source dwell positions and specify the optimal sequence of dwell times to customize dose distributions for individual patients.

We report the use of CT simulation and multichannel vaginal cylinders on the Oncentra® Brachy treatment planning system for high-dose rate intracavitary brachytherapy in four patients with vaginal neoplasias. For each case, we calculated the dose coverage to the clinical tumor volume and to the bladder and rectum (D2cc and D1cc). We then compared these values to those calculated for hypothetical treatment planning with single-channel vaginal cylinders normalized to a depth of 0.5 cm and to the edge of the clinical target volume.

Case reports

Case 1

A 67-year-old female underwent a hysterectomy for benign reasons 21 years prior to presentation and subsequently developed diffuse large B-cell lymphoma stage IA that was unrelated to the hysterectomy. She was treated with six cycles of rituximab in combination with doxorubicin, cyclophosphamide, vincristine, and prednisolone (R-CHOP). Eighteen months later, she presented with vaginal bleeding. A polyp was reportedly identified near the vaginal apex and was surgically removed. Pathology unexpectedly showed high-grade leiomyosarcoma with positive margins. To ensure negative margins, clinicians recommended further resection followed by adjuvant radiation therapy for local tumor control.

The vaginal apex and extravaginal margin were surgically resected. No residual leiomyosarcoma was identified. At a multidisciplinary cancer conference, clinicians agreed to perform EBRT of the pelvis with a total dose of 4500 cGy administered in 25 fractions over 5 weeks. This treatment was to be followed with three vaginal cuff BT treatments.

CT simulation and BT treatment planning were performed using inverse planning simulated annealing (IPSA) on the [DEVICE NAME] with a multichannel vaginal cylinder of 2.5 cm diameter. To ensure optimal clinical target volume, target volume was defined by the treating physician, compared with the patient's surgical report, and reviewed by a gynecology oncologist and by other radiation oncologists involved in the care and initial evaluation of the patient.

The treatment plan specified using a total of nine dwell positions to deliver 600 cGy to the clinical target volume. This plan ensured that dose to the bladder and rectum was restricted to less than 70% of the prescription isodose (Table 1). Only 1.6 cc of bladder tissue and 1.4 cc of rectal tissue were to exceed a dose of 420 cGy.

Results of treatment planning showed that D2cc for the bladder and rectum were 68 and 79 cGy, respectively. In contrast, for single channel normalized to a depth of 0.5 cm, D2cc of the bladder and rectum were 79 and 75 cGy, respectively, and for single channel normalized to the edge of the clinical target volume, D2cc of the bladder and rectum were 86 and 82 cGy, respectively. The radiation dose delivered to 90% of the clinical target volume (D_{90}) was 114% of the prescription dose when the multichannel cylinder was used. This D90 was lower than for either of the single-channel methods.